

Spaghetti Wrist: Good Prognosis with Adequate Surgical Technique and Early Physiotherapy

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ABSTRACT

Few studies on spaghetti wrist have been published. The majority of those works are retrospective reviews of cases of different surgeons or centres and hence conflicting data. Moreover, a consensus has not been reached for what should be considered a spaghetti wrist injury. The authors present a study consisting of 11 patients (10 males and 1 female) all performed within a 2 years period with average follow-up of 18 months. All cases were operated by the senior author and rehabilitated by the same physiotherapist. The average age of patients was 34 and none of the cases was a suicidal attempt. The injuries were defined as occurring between the distal wrist crease and the flexor musculotendinous junctions involving at least 5 tendons including one mixed nerve and sometimes an artery. The outcome of tendons repair and finger range of motion was excellent in all cases and this can be attributed to early mobilization by using active dynamic splints. Nerve repair was done in group-fascicular pattern with median nerve showing a faster and better recovery than the ulnar nerve. Sensory return was better than previously reported in other published works with all 9 patients with median nerve showing a 5-7mm two-point discrimination. The muscles innervated by the median nerve showed good function and adequate bulk. As for muscles innervated by ulnar nerve, despite an excellent opposition, fingers' abduction and adduction was slow and incomplete. Immediate surgical interference in cases of spaghetti wrist injuries with adequate and early physiotherapy can yield favourable results.

INTRODUCTION

The distal volar forearm and wrist contains 16 different tubular structures (12 flexor tendons, 2 nerves and 2 arteries) all packed together under relatively thin skin coverage. Deep laceration to this region usually involve more than one of these structures hence the name of spaghetti wrist or full-house syndrome. Such trauma can cause tremendous disability even if involving a limited number of these components. For instance complete transaction of either the median or ulnar nerve can have crippling outcome even if combined with few tendons [1,2].

Despite their relatively frequent occurrence, these injuries are still surrounded with great controversies [3-6]. The extent of injury to be classified as spaghetti wrist is still disputed ranging from the minor form of three completely transacted structures (artery, nerve and tendon) to major trauma with laceration of at least 10 structures including median and/or ulnar nerve. Moreover, the sparse data in literature is mainly concerned with retrospective studies of multiple centres with different surgeons and contains conflicting data both functionally and psychologically [2,6,7].

The main objective of this study is to review the patients' criteria, causes of injuries and the outcome of an average 18 months follow-up of 11 cases with deep cut wrists. The minimal definition of spaghetti wrist was also redefined to at least 5 tendons, beside a nerve, being involved in each case. Although the number of cases is small yet this study is different in that all the patients were operated by a team composed of the senior author and rehabilitated and followed by the same physiotherapist while other published works depended mainly on retrospective studies of different surgeons or centres.

PATIENTS AND METHODS

The study includes eleven patients (10 males, 1 female) who were operated upon by the author from June 2006 to May 2008. The data of the patients are shown in Table (1). Spaghetti wrist injuries were defined as lacerations occurring between the distal wrist crease and the flexor musculotendinous junction involving at least one nerve at least 5 tendons and sometimes one vessel. All traumas were sharp lacerations so no gunshots or crushing injuries were included. In none of the eleven cases were the two arteries transacted necessitating immediate hand revascularization.

Table (1): Summary of injuries.

Patient's gender	Age (years)	Tendons*	Nerves	Arteries
Case 1 (male)	27	PL, FCR, FDS 3 and 4 FDP3	Median	–
Case 2 (male)	54	PL, FCU, FDS 3-5, FDP 4 and 5	Ulnar	Ulnar
Case 3 (male)	44	PL, FCR FDS 2-4	Median	–
Case 4 (male)	22	PL, FDS 2-5	Median	–
Case 5 (female)	37	PL, FCR FDS1 and 2 FDP 2	Median	–
Case 6 (male)	26	FCR, FCU FDS 2-4 FDP 2,3	Median and Ulnar	Ulnar
Case 7 (male)	52	PL, FCR, FCU FDS2-5 FDP 4	Median	Radial
Case 8 (male)	22	FCR, FCU FDS 2-5 FDP 3-5	Ulnar	–
Case 9 (male)	29	PL, FCR FDS 2-4	Median	–
Case 10 (male)	25	FCR, FCU, FDS2-5 FDP2-5	Median and Ulnar	Ulnar
Case 11 (male)	36	PL, FCR, FCU, FDS2-4	Median	–

* PL: Palmaris longus; FCR: Flexor carpi radialis; FCU: Flexor carpi ulnaris; FDS: Flexor digitorum superficialis; FDP: Flexor digitorum profundus. The numbers designate the fingers involved starting from index finger taking number 2 and progressing medially till the little finger with number 5.

Operative approach:

Under general anaesthesia and tourniquet approach, the wrist was kept in 40° flexion and the wound was inspected. The involved tendons were identified and the proximal and distal cut ends were tagged. Nerves are tagged with prolene 6-0 to its sheath. If the existing laceration is not providing adequate exposure extension is planed according to the zone needing further inspection.

Once the identification was completed, finger flexor tendons were repaired in deep to superficial fashion with 4-0 prolene core suture followed by 5-0 epitenon sutures. Fingers cascade was checked with each tendon repair and after completion of all affected fingers before proceeding to the next step. In four of the eleven cases, the arterial repair was performed following the finger tendons repair. In two of the four patients, the vascularity of the hand was found impaired despite an intact second artery. The tourniquet was released and vascularity rechecked for adequate flow followed by nerve repair under microscope using 9-0 Ethilon (Ethicon) sutures in group fascicular fashion. Wrist flexors

were then repaired using 3-0 prolene core suture and 5-0 prolene (Ethicon) epitenon repair. Good haemostasis and wound closure in 2 layers completed the procedure.

Postoperative rehabilitation:

The whole hand including the digits were put into a bulky dressing and a dorsal splint was applied to keep the wrist in 30° of flexion, the metacarpophalangeal joints in 70° of flexion and the interphalangeal joints in neutral position. Passive flexion-active extension using rubber band traction was started at day 3. This position was kept for 4 weeks and the splint was never removed during this period. At 4-6 weeks, the splint was changed with another one maintaining the wrist in neutral to 10° of flexion and the metacarpophalangeal joints in 40° of flexion and the same program of rubber band traction was continued with a wider range of movement. The nerve regeneration could be followed at that stage as an advancing Tinel's sign. At 6-8 weeks, the splint was removed and light activity of daily living were allowed while warning the patient that his hand will remain numb for a certain period and

should avoid any extremes of temperature or rough surfaces. The patient was never allowed for full activity until protective sensation reached the distal phalanges. Functional assessment was performed according to Kleinert and Verdan criteria: Excellent (individual tendon function 85% to normal active motion or to finger flexion 1cm or less to the distal palmar crease), good (84-70% of total active motion or 2.0cm from distal palmar crease), fair (69-50% of total active motion) or poor (fixed contractures or adhesions) [8].

RESULTS

A total of ten males and one female, average age 34 sustained spaghetti wrist injuries. The most frequent mechanisms of injury were accidental domestic glass lacerations. No suicidal attempt was recorded. The most frequent structures involved were the flexor digitorum superficialis tendons which was involved in all eleven cases. The radial triad i.e. flexor carpi radialis, Palmaris longus and median nerve came second in incidence. Each structure was found injured in 8 out of the 11 cases. The combined injury of those three was found in 5 out of 11 cases. Flexor carpi ulnaris came fourth,

followed by flexor digitorum profundus, ulnar nerve and ulnar artery. The radial artery was the least in incidence being involved in one case while none of the eleven cases presented with the affection of the flexor pollicis longus.

In all eleven patients, range of motion of involved digits and wrist was excellent. The protective sensation was recovered in all patients and corresponded simultaneously with the progressing Tinel's sign. Two-point discrimination ranging between 5-8mm returned in all 9 patients with median nerve injury. One patient of the four suffering ulnar nerve injuries showed a 5-10mm response. The other three patients with ulnar nerve injuries showed only protective sensation beside prolonged parasthesia of more than one-year duration. Intrinsic muscles supplied by the median nerve showed adequate recovery while those supplied by the ulnar nerve showed more prolonged and incomplete recovery. Fingers abduction and adduction was weak and mass movement was the rule. The grip strength was weak in two patients with combined median and ulnar nerve injuries. No neuroma or tendon ruptures were observed during the follow-up period.



Fig. (1): Case 2 (Above left) A 54-year old male patient sustained a deep cut wound of the distal one third of the right forearm after hitting the window glass. (Above, right) At 50 days after repair of the cut 8 structures. The dryness of the lateral one third of the palm and clawing of the medial 2 fingers is evident as ulnar nerve regeneration evident by progressing Tinel's sign reached the distal wrist crease. (Below left and right) At 18 month follow-up full range of motion is achieved.

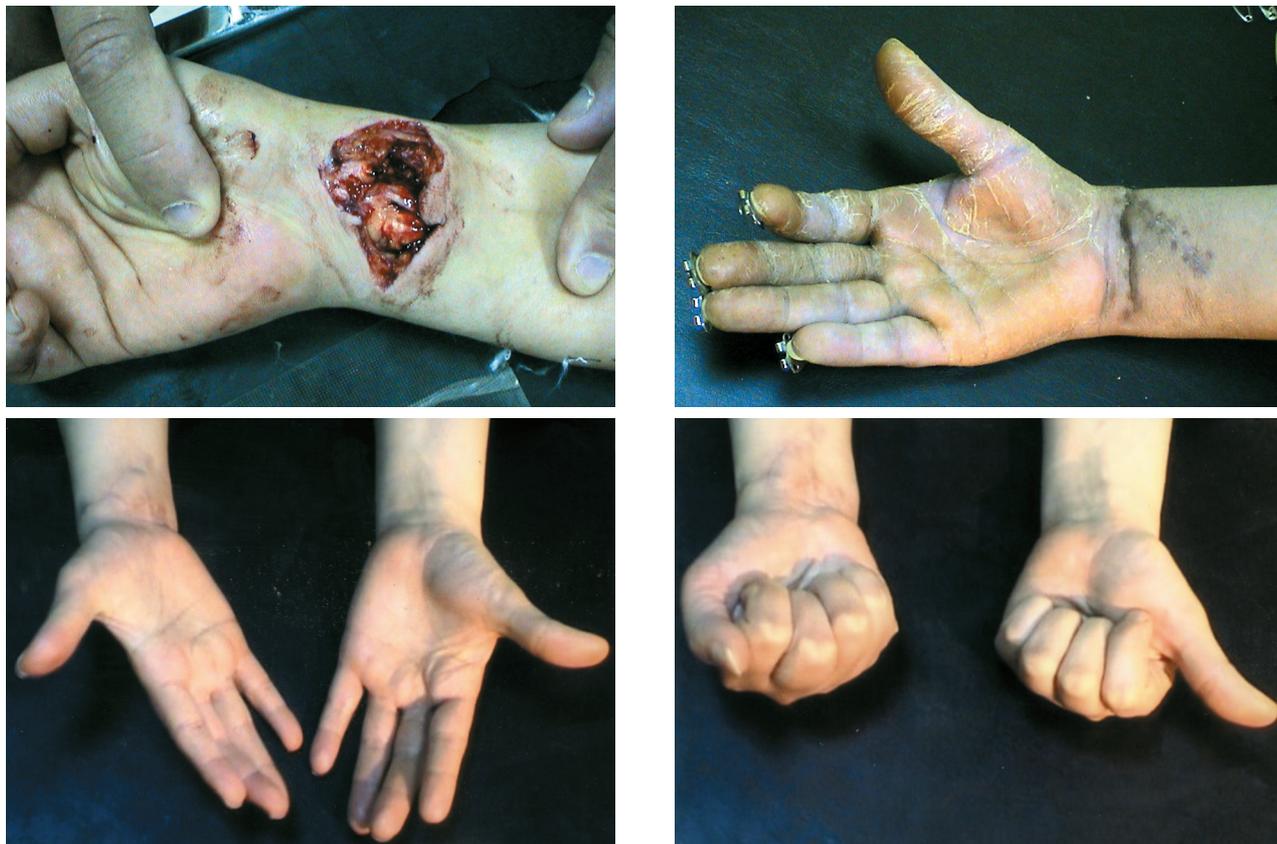


Fig. (2): Case 5 (Above, left), the right wrist of a 36-year old female patient with penetrating cut wound severing the 2 flexor of the index finger the flexor superficialis of the middle, flexor carpi radialis, Palmaris longus and median nerve. (Above, right) 40 days postoperative view showing the distribution of dryness is similar with that of sensory loss and the denervated first lumbrical is responsible for flexed deformity of the index finger. (Below, left) 10 months postoperative showing thumb in full abduction and fingers in full extension with comparison to the left hand. (Below, right) the patient is flexing all the fingers.

Fig. (3): Case 7 (Above) a 48-year old male presented with deep laceration of left wrist and forearm after a fall on a glass board. 9 tendons and median nerve were severed. The radial artery was also cut and both ends were ligated elsewhere. (Below, left and right) At 12-month follow-up there is full range of motion; a vein graft was used to reconstruct the radial artery.



DISCUSSION

Spaghetti wrist injuries are serious traumas that can have severe sequelae if not managed correctly from the start. The involvement of nerves in the injury even with minimal tendons lacerations may lead to devastating and crippling outcome unless an experienced surgeon is allowed to treat the condition immediately [9]. Despite their relatively frequent occurrences, few and controversial data are available to define and propose a possible prognosis for these injuries.

Puckett and Meyer introduced the term "spaghetti wrist" when any 3 structures either tendon, nerve or artery are simultaneously cut [3]. Hudson and deJager suggested the inclusion of the median and ulnar nerves as a prerequisite to classify the injury as spaghetti wrist [4]. Other authors used the term to coin injuries with at least 10 divided structures including either median or ulnar nerves [5]. In this study, the patients included are those having a nerve and at least 5 tendons to be sure that at least two digit flexor tendons are included apart from the three wrist flexors. Both ulnar and median nerve are mixed nerves each having a crucial importance to either the sensory and motor function of the hand. It is the author opinion that the nerve inclusion is a must to distinguish such trauma from mere cut unimportant tendons or artery, which may have less impact on the hand function. Moreover, nerve injury in itself add to the difficulty of the operation as the surgeon has to identify, reorient and adequately repair the cut ends of the nerve if an optimum result is to be expected.

In Puckett and Meyer series of 38 spaghetti wrists, ninety seven percent of patients had a good to excellent range of motion. No patient required tenolysis or suffered tendon rupture. 8 patients only had protective sensations while 6 patients had significant return intrinsic muscle activity [3].

Widgerow reported 19 cases using a definition of at least 10 injured structures including at least one major nerve and usually one major vessel [4]. Of the 19 patients, ninety five percent had good to excellent range of motion. Of the 14 patients with ulnar nerve injuries, 5 patients demonstrated clawing remaining while protective sensation returned in 7 out of 11 patients suffering from combined nerve injury.

In their 8 years retrospective study, Chin et al., included 60 patients (41 male and 19 female) involving at least 3 transected structures with one nerve and usually one vessel [1]. The most frequent

injured structure was flexor carpi ulnaris 66.7% followed by the median nerve 60%. The most common pattern of injury involved the ulnar nerve, ulnar artery and flexor carpi ulnaris also known as ulnar triad. The authors explained this predilection to the fact that in their study population, most patients were unemployed young men who were either intoxicated, angry or both and hitting glass with the ulnar border of their hands. In the subset of 19 patients available for follow-up examination, range of motion was excellent in 12 and good in 7. The affected nerves were repaired in perineural pattern and no dynamic splint was used in rehabilitation period. Intrinsic muscle recovery was good in 7 patients and fair to poor in 5 patients. Sensory return was disappointing with only 7 patients developing protective sensation. Two points discrimination returned in 5 patients with only 2 having a two points discrimination less than 6mm.

Noaman completed a more recent retrospective review of 42 patients [10]. A total of 31 males and 11 females, average age of 17.1 years (range, 2-40 years), sustained spaghetti wrist injuries. The most frequent mechanisms of injury were accidental glass lacerations (55%), knife wounds (24%), and electrical saw injuries (11%). The most frequently injured structures were median nerve (83%), flexor digitorum superficialis 2-4 tendons (81%), flexor digitorum profundus 2-4 tendons (66%), ulnar nerve and ulnar artery (57%), and flexor pollicis longus (40%). Combined flexor carpi ulnaris, ulnar nerve, and ulnar artery (ulnar triad) injuries occurred in 31%, while combined median nerve, palmaris longus, and flexor carpi radialis injuries (radial triad) occurred in 43%. Simultaneous injuries of both median and ulnar nerves occurred in 40.5%. Simultaneous injuries of both ulnar and radial arteries occurred in 14%. Neither artery was injured in 30.9%. Follow-up has ranged from 1 to 8 years, with an average of 46 months. Only four patients have been completely lost to follow-up. Range of motion of all involved digits (tendon function) was excellent in 34 patients, good in 3 patients, and poor in only 1 patient. Opposition was excellent in 31 patients, good in 5 patients, and poor in 2 patients. Intrinsic muscle recovery was subjectively reported to be excellent in 29 patients, good in 7, and fair to poor in 2 patients. Minor deformity (partial clawing) was reported in 4 patients and 1 patient has major deformity (total clawing). Sensory recovery was reported, excellent in 32 patients, good in 5 patients, and fair in only 1 patient.

In this study, 10 out of 11 patients were male with no report of suicidal attempt. Five males were

injured after being angry and hitting a pane of glass while the remaining six (including the female patient) contributed their injuries to lack of prudence. The most common involved structures were the flexor digitorum superficialis tendons (11/11) with common affection of the middle three fingers. Palmaris longus, flexor carpi radialis and the median nerve all sharing the same incidence (8/11). Those 3 structures were simultaneously affected (radial triad) in (5/11). Unlike other reports, flexor pollicis longus was not affected in any case. In all eleven patients, range of motion of involved digits and wrist was excellent and this is most likely due to early mobilization through active dynamic splint.

The earliest sign of nerve regeneration is the progressive return of sweating along the distribution of the affected nerve. The protective sensation was recovered in all patients. Two-point discrimination ranging between 5-8mm returned in all 9 patients with median nerve injury and in one patient of the four presenting with ulnar nerve injury. The three other patients with ulnar nerve injury showed 10-15mm two-point discrimination as well as prolonged parasthesia of more than one-year duration. The group fascicular repair of nerves is mainly responsible for the better outcome of sensory recovery when compared with other reports using epineural repair [1-4]. Touch sensation never recovered and patients reported such affection in their daily activity as when trying to hold a piece of cotton or tearing bread. Such data came in accordance with other previous reports stating that fine touch never returned [2,11,12].

Intrinsic muscles supplied by the median nerve showed adequate recovery while those supplied by the ulnar nerve showed more prolonged and incomplete recovery. Despite an excellent opposition, fingers' abduction and adduction was slow, weak and mass movement was the rule. Despite this weakness, hypothenar wasting or guttering was not seen in any of the four patients with ulnar nerve injury. The grip strength was weak in the two patients suffering combined median and ulnar nerve injuries. While other authors had a small number of permanent deformities due to clawing such sequalea were not noticed by the author. However, the results obtained in this study confirm the fact that intrinsic muscles supplied by the ulnar nerve never regain normal activity especially the interossei.

Conclusion:

The number of tendons injured doesn't seem a major factor in determining the prognosis of spa-

ghetti wrist injuries since the outcome in most studies including this one showed that the functional outcome is excellent to good as long as the patient was subjected to adequate physiotherapy. The authors suggest that five tendons inclusion with any of the two mixed nerves is sufficient to categorize such injury as spaghetti wrist. Moreover, the predilection of either ulnar or radial triad in spaghetti wrist injuries is subject to variation according to the study population and cannot be used as a scientific base to explain the injury. Group fascicular repair of the nerves and early mobilization through dynamic splinting with strict follow-up are mandatory for optimum results. Patients with ulnar nerve injury have more problems with intrinsic muscle function and sensory recovery compared with median nerve.

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