

Original Research Article

Analysis of functional outcome of complex forearm injuries

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ABSTRACT

Background: Complex forearm injuries are often associated with contamination, crushing, loss of tissues and patient arrives at odd hours when specialists are not available. These injuries can lead to complications like infective non-union, stiffness, disabilities and secondary amputations.

Methods: 23 patients having complex forearm injuries treated primarily at tertiary care center by single surgeon were included in the study. Pinch strength, grip strength, residual deformity and DASH score was assessed at final follow-up. In 23 patients treated, 16 patients underwent primary internal fixation of both bone, primary external fixator was done in 4 patient, delayed fixations in 6patients, primary bone grafting in 3 patients and in 1 patient delayed bone grafting was done Skin grafting was performed in 6 cases, and flaps in 13 patients. Vascular repair was done in four patients.

Results: All 23 patients came for follow-up. An average number of surgery performed per patient was 3.81 and mean hospital stay of 28.2 days. The mean duration of follow up was 47.2 months. The average DASH score was 10.24 with average key and tip pinch and grip strength of 62.24%, 58.48% and 54.75% respectively. 3 patients had superficial infection and two patient deep infections. Superficial infections were managed with IV antibiotics. The patients with nerve and vascular injuries had higher DASH score.

Conclusions: Early wound coverage can improve functional outcomes. Training in plastic coverage of wounds using pedicle flaps and skin grafting, microsurgical nerve and vessel repairs for orthopedic surgeon can be of great help for the patients.

Keywords: Open fractures, Complex injury, Forearm fracture, Flaps, DASH

INTRODUCTION

A trauma related death occurs in India every 1.9 minutes.¹ No exact data for the upper limb injuries is available to judge the gravity of the problem. Such injuries are common in young age group who are the earning bread for the family. In the developing world, complex extremity injury is the one of the problems associated with significant morbidity and it greatly affects the socioeconomic status of the patient. Complex forearm injuries involve multiple tissue and often

associated with contamination, crushing and loss, arrives at odd emergency hours when specialists are not available, leads to complications like infective nonunion, disabilities and primary or secondary amputations.² The forearm is the important link between the upper proximal part of the extremity and the hand, which is the functional end organ. The complexity of the forearm and hand anatomy can be a challenge for the surgeon. Inadequate or poor management of such injuries can lead to poor function and sometimes end up into secondary amputation which is a financial loss and affects the

psychological aspect of the patient as well.^{3,4} Emergency debridement and early soft tissue coverage with stable skeletal fixation is the key factors in management of such trauma.⁵ Salvage of the upper limb without any sensation or motor function is not acceptable; the salvaged limb cannot be compared with prosthesis in this era of advanced microsurgery. Nowadays reasonable movement of salvaged limb with at least protective sensation is the goal of reconstruction. The ultimate aim is to restore sufficient function, so that the patient can perform their activities of daily living, and return to work. Such injuries are uncommon in the western world due to better traffic sense and preventive measures in the industries. Literature is sparse in the management of such forearm injuries, hence the study on the functional outcome of such injuries will be of relevance and of greater help before embarking on the limb salvage in complex forearm injuries.

METHODS

A retrospective study was done in Department of Orthopedics tertiary care center. This study was examined and approved by the ethical committee. We went through the hospital records to find out patients treated for mangled forearm during year 2008 to 2013. Ours is rural tertiary center where full time plastic surgeon is not available. The patients having multiple tissue injuries with crushing and contamination treated right from beginning by single orthopedic reconstructive surgeon were included. The sharp cut injuries with or without skeletal injuries, major forearm replants, and patients referred to us between the staged management of such injuries for expert care were excluded. 23 such patients were selected and the records were examined and preoperative data such as mode of injury, demographic data, fracture classification, loss of tissue and grade of open fracture (Gustilo Anderson classification) and MESS score were collected.^{6,7} According to Gustilo Anderson classification, 21 patients into type IIIB and two patients in type III C. The mean age was 32 years (range 9–54 years) most of the patients were young and active adults. There were 21 males and 2 females. The injuries involved 16 dominant and 7 non dominant hands. The mean MESS score was 4.26 ranging from 2 to 7. Out of 23 patients, 14 had vehicular accidents and 9 were involved in various industrial injuries. All the patients were having injury to musculotendinous units. There were 8 nerve injuries (5 median and 3 ulnar). The nerve injuries were further divided into proximal and distal injuries. Primary nerve repair was done in 2, Delayed repair in 2 and 3 patients underwent nerve grafting. One partial injury was managed conservatively. In 23 patients treated, 16 patients underwent primary internal fixation of both bone, primary external fixator was done in 4 patient, delayed fixations in 6 patients, primary bone grafting in 3 patients and in 1 patient delayed bone grafting was done. Musculotendinous repair was done in 13, loss was left unrepaired in 7 patients and tendon transfers were done in 2 patients. Flexor tendon repair were done in two patients, Extensor tendon repair in three patients and

injuries to palmaris longus, partial loss of brachioradialis, pronator quadratus were left unrepaired. There were 8 patients with vascular injury (2 brachial artery injury at elbow and 6 radial artery injury at distal forearm level). Brachial vessels were repaired and radial artery was ligated in 4 patients and repaired in two patients. Crushed radial artery was ligated after performing intraoperative Allens test. Patients were contacted through phones and letters and called for final clinical and radiological evaluation for functional outcome and residual disability. In follow-up, X-rays of the limb was taken for bony union and joint stability. Patients were examined by senior orthopedic surgeon and physiotherapists. Sensation were checked with Semmes Weinstein filament and the 2 PD with disk criminator. The power of the upper extremity was checked with help of Jammer dynamometer for grip and pinch strength and compared with unaffected other limb. Functional outcome of the upper limb was assessed using the DASH questionnaire.⁸

RESULTS

All the 23 patients returned to follow-up. The average duration of follow up was 47.2 months ranging from 29 to 89 months. Average number of surgeries done was 3.81, ranging from 2 to 10. The average hospital stay was 28.2 days ranging from 8 to 59 days. Eight patients had nerve injuries in which 2 underwent primary repair, two underwent delayed repair, three underwent nerve grafting and one was managed conservatively.

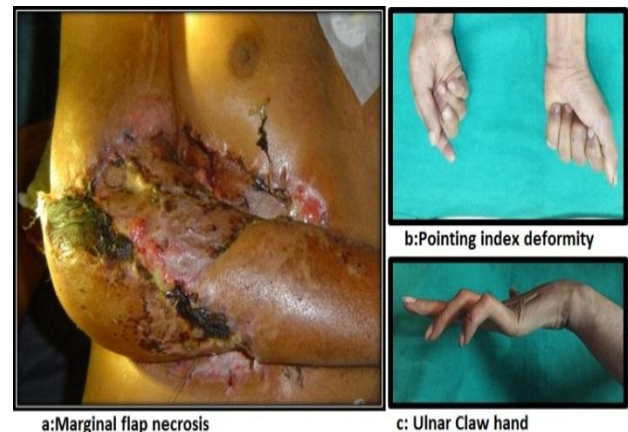


Figure 1: Complications.

The patients with primary repair of median and ulnar nerve gained S2 and S3+ sensory recovery respectively. The patient with median nerve substance loss with nerve grafting achieved S2 sensory recovery in the patient with combined ulnar nerve injury with AIN injury sensory recovery in little, ring, middle, index finger was S3 and S2 in thumb. Partial injury and contusion were treated conservatively which recovered fully (Table 1).

13 fractures of both bones forearm went for primary union without any infection, out of 13 patients, 3 required primary bones grafting for segmental bone loss (Figure

6). One patient with External fixator for radius with flap on dorsum of hand was taken for secondary plating with bone grafting after 1 month. In one patient there was

implant failure treated with bone grafting and 3.5 dynamic compression plates.

Table 1: Nerve injury and results.

Case no	Type of nerve injury	Repaired Yes/No	Sensation	Grip strength gain %	Pinch strength %		DASH score
					Tip	Key	
1	Partial median nerve injury	Conservative	S3+2PD of 3-7 mm	58.82	51	77.1	9.48
2	Median nerve loss	Nerve grafting	S2 protective sensation	13.33	41.5	49.2	20.68
3	Median nerve injury	Delayed repair	S2 2PD of 7-12 mm	22.27	0	37.8	40
4	Ulnar nerve injury, AIN injury	Nerve grafting	S3 in fingers, S2 in thumb 2PD of 6 to 13 mm	37.5	27.77	32.78	16.37
5	Median nerve injury	Primary repair	S3+2PD of 7-8 mm	53.12	45	70.67	14.16
6	Ulnar nerve loss	Nerve Grafting	S2 2PD of 8-11 mm	41.45	62.7	42.49	18.12
7	Median Nerve injury	Delayed repair	S3 2PD of 7-12 mm	41.86	52.1	61.8	16.56
8	Ulnar nerve injury	Primary repair	S3+2PD of 5-11 mm	47.36	66.9	66.8	10.33

Mean DASH score 18.21.

Table 2: Type of flaps.

Type of flap	Number of patients	Infection	
		Superficial	Deep
Abdominal flap	5	1	0
Groin flap	2	1	0
Chest arm flap	5	0	1
Local transposition flap	2	1	1

Table 3: Timing of flap.

Timing of flap	Number of patients	Infection	
		Superficial	Deep
Emergency (within 24hours)	3	0	0
Early (within 24 to 72 hours)	6	1	0
Delayed (after 72 hours)	5	2	1
Total	14	3	1

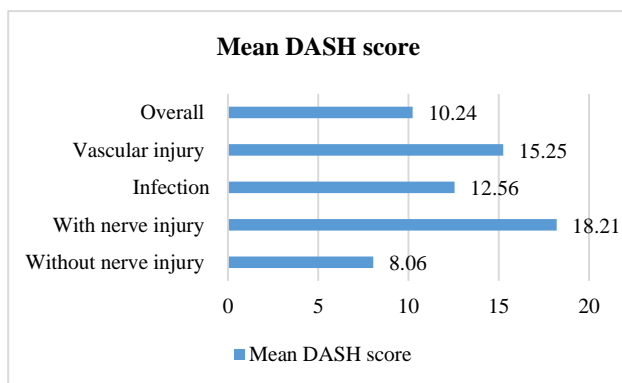


Figure 2: Mean DASH score.

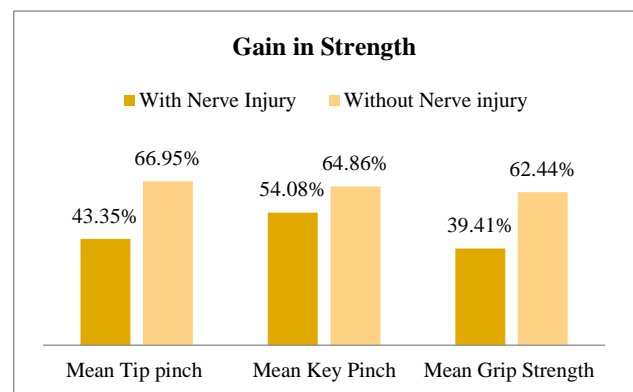


Figure 3: Gain in strength.

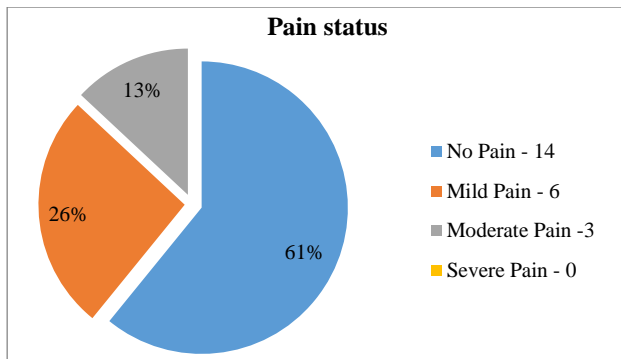


Figure 4: Pain status at final follow-up.

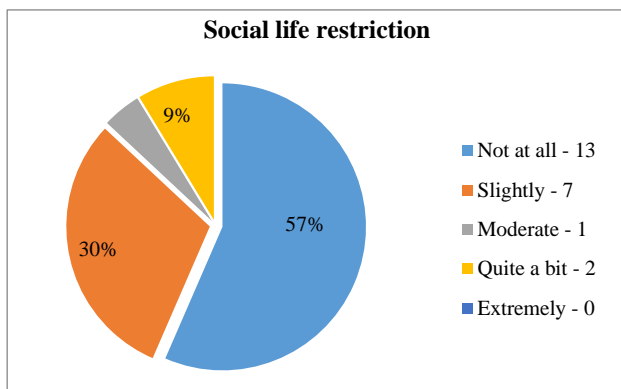


Figure 5: Social life restriction.

For wound coverage 6 Split thickness skin grafting, 3 emergency flaps, 6 early flaps, 5 delayed flaps were done (Table 2 and Table 3). There were overall 7 patients with infections out of which 5 patients were with flaps, three having superficial infection and two having deep infection. Superficial infection was treated by local debridement, wash and IV antibiotics and deep infection was treated with debridement and removal of implant after bony union. One patient underwent wrist arthrodesis as secondary procedure because of the extensive loss of flexor and extensor tendons. Flap related complications were seen in 4 patients out of which marginal flap necrosis (Figure 1) was seen in 3 and flap hematoma in one patient. Debridement and resuturing of flap was done in 2 patients and one was managed conservatively. No secondary flaps were required and all the flaps healed at final follow-up. The median length of hospitalization for those developing flap complications was 37 days compared with 16 days for those who did not develop any complications. One patient with ulnar nerve injury with loss for which nerve grafting was done, developed clawing of 4th and 5th finger. One patient with median nerve repair had pointing index deformity at the final follow-up (Figure 1). The average DASH score was 10.24 ranging from 3.8 to 40. The average DASH score of patients with nerve injury is 18.21 and with vascular injury is 15.25 (Figure 2). Average tip pinch was 58.48% (range 0 to 94.44%); key pinch was 62.24% (range 33.33 to 81%) and grip strength was 54.75% (range 13.33 to 85.71%). Patients with nerve injuries had lower grip and

pinch strength (Figure 3). All the patients were back to same job except one who had to change his dexterity. At the final follow-up 17 patients (61%) were pain free and 6 had mild pain (Figure 4). 13 patients (57%) had no restriction and 2 had quite a bit restriction in social life (Figure 5) and all were satisfied with the function of the limb (Figures 6-9).

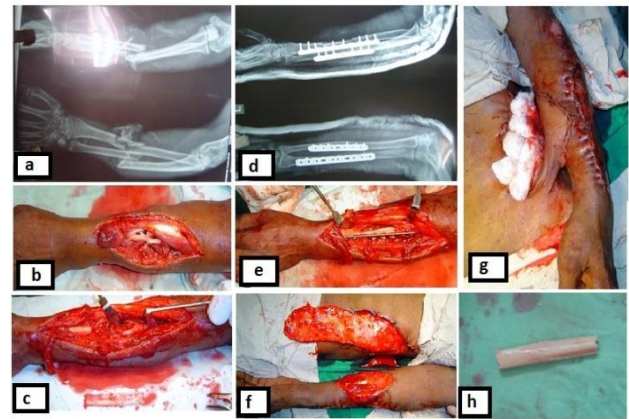


Figure 6: Patient A with complex forearm injury.

a: Pre op X-ray; b: Wound with tendon loss; c: Bone loss; d: Immediate post-operative X-ray; e: Plating with fibula autograft; f: Flap raised; g: Flap sutured; h: Fibula autograft.



Figure 7: Patient A with complex forearm injury follow up X-rays and clinical pictures.

Table 4: Infection rate.

Total no of patients	Infection rate		
	Superficial	Deep	Total
23	5 (21.73%)	2 (8.69%)	5 (30.43%)



Figure 8: Patient B with complex forearm injury.
a: Open wound on volar aspect with contamination; b: Post debridement; c: Vascular injury; d: Pre op x-ray with peri implant fracture of both bone forearm; e: Local transposition flap.



Figure no. 9: Patient B with complex forearm injury follow up X-rays and clinical pictures.

DISCUSSION

Historically, the primary method of treating mangled injuries of limbs has been amputation. Surgeons long ago learned that without effective treatment, devascularized, contaminated, or crushed tissues, along with open fractures often led to local life threatening infections; and this could be avoided with early amputations and stump debridement. The risk of infection in vascular compromised and contaminated tissue is high and development of infection will prolong treatment and may

compromise the outcome.⁹ With the advent of Antibiotics and advances in Anesthesia and surgical care, more aggressive salvage efforts were undertaken. In the 1950s there was a tendency to treat mangled injuries with minimal debridement and a goal of preserving length. In the 1970s, the concept of delayed closure to reduce infection risk was popularized and incorporated into the treatment of mangled upper extremities injuries. In 1980s management of mangled injuries became increasingly aggressive, combining radical debridement with revascularization, early reduction and fixation of fractures, and early vascularized soft tissue coverage with flaps.¹⁰

Chapman et al and Anderson et al showed the overall union rate of 97.3% in forearm fractures with infection rate of 2.9% in open fractures and 0% in closed fractures.^{11,12} In our series the overall union rate of primary fixation was 84.61% and infection rate of 12.5%.

The identification and growing experience with reliable axial pedicle flaps, and micro surgical free flaps provided a wide range of new opportunities in salvaging mangled extremities. Godina et al work showed that with a radical debridement and early microsurgical soft tissue reconstruction within 72 hours, infection risk, morbidity and time to healing were all dramatically improved.¹³ Emergency free flap cover for the upper limb with primary tendon reconstruction and nerve repair with skeletal stabilization by Lister and Schekar bought a breakthrough in improving functional results and reducing the stages of reconstruction and saving the total duration of treatment.¹⁴ In our series 6 Split thickness skin grafting, 3 emergency flaps, 6 early flaps, 5 delayed flaps were done. Infection rate was 21.73% in patients with flaps (Table 3 and Table 4). This is comparable with 1.5% of infection rate in early group and 17.5% infection rate in delayed group of Godina et al series.¹³ This was because of wound exposed for longer time leads to loss of tissue due to fibrosis and desiccation and drying tendons and bones and repeated debridements. We feel it is not necessary to use free flaps only, pedicle flaps can perform equally well. The overall infection rate in our series was 30.43% out of which 21.73% were superficial infection managed conservatively and not requiring secondary procedure (Table 4).

Peripheral nerve injuries are frequent and generate significant deficits.¹⁵ A nerve grafting done in tensionless manner has superior results to that of primary nerve repair with tension.¹⁶ Several factors, such as age, injury level, graft length and denervation time, have been claimed to influence on the results of nerve grafting.^{17,18} In our study we have much better results in distal nerve lesions, which is in correspondence with other published studies.^{19,20} Lower nerve injuries are much closer to the motor endplates and sensory receptors and regenerating fibers have to elongate for a lower distance to reach targets in the hand.¹⁵ In our series the recovery of primary repair was better than grafting and delayed repair. There

was no significant difference in sensory recovery of median and ulnar nerves. The mean DASH score of patients with nerve injuries in our study was 18.21 ranging from 9.48 to 40. In series of 44 patients with ulnar nerve repair Barrios et al concluded that the early repair of clean cut peripheral nerve section by fascicular or epineural sutures gives best chance of recovery.²¹ Grafting should be performed within 3 months and no later than 1 year. The presence of multiple nerve injuries and tendon injuries and vascular injuries had unsatisfactory results. The presence of one or more major nerve injuries is the most significant predictor of long-term functional outcome.

Musculotendinous repairs were done in 13 patients. Upper extremity crush injuries should be reconstructed despite the presence of a major nerve injury, but these patients should be cautioned about potential limitations of long-term functional recovery.²² Proper examination of the injured limb and application of latest medical and surgical technologies helps the surgeon to make the critical decision of reconstruction vs. amputation to achieve the best possible functional outcome for the patient at the earliest after the injury.²³ It has been proved that a reconstructed mutilated hand even though it takes multiple surgical stages; it gives better functional results than the best available prosthesis and better patient satisfaction.²⁴ Treatment of course is also an important key to the outcome. Hence, adherence to the principles discussed here can make a big difference to eventual outcome. It is important to realize that treatment begins from the first encounter, through the multiple surgeries and rehabilitation. The medical treatment ends only when both patient and surgeon agree that the result is static, permanent, and the patient has learnt to adapt with the disability if all present.

CONCLUSION

All injuries are different from each other and needs expert care right from beginning. Radical debridement with loupe magnification is the key in open fractures. Early wound coverage can improve functional outcomes. So, training in plastic coverage of wounds using pedicle flaps and skin grafting, microsurgical nerve and vessel repairs for orthopedic surgeon can be of great help for the patients.

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Conflict of interest: None declared

Ethical approval: The study was approved by the institutional ethics committee

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