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Hand Injuries at Work: Causes, Spectrum and Management

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ABSTRACT

Background: Hand injuries are common and an increased surge has been seen secondary to the use of machines. The spectrum of injuries is wide ranging from injuries requiring few stitches to requiring specific reconstructive procedures such as skin grafting, pedicled flaps to free flaps or amputations depending on severity and pattern of injury.
Methods: This was a hospital-based single-arm prospective study conducted in the Department of Plastic and Reconstructive Surgery for 3 years. 46 patients were included. Each record was analyzed as per the etiology, the treatment received, the reconstructive procedures done, and the functional and aesthetic outcomes.
Results: Most of the affected individuals were young, the mean age of the patients was found to be 23 years. Among the injured 85% were males. The dominant hand (right hand) was more frequently injured in 74% of cases. In total 18 patients had some of the affected areas amputated; this included formalization of traumatic amputations. It is also significant that twelve patients underwent revascularization and four reimplantations. Twelve patients underwent groin flaps as a primary or delayed primary in the same admission. Ten patients required split skin grafting and three. Two patients were managed with FDMA flap for thumb defect, one patient was managed with reverse radial forearm flap for compound defect dorsum of thumb, and another with free lateral arm flap for compound defect of thumb.
Conclusion: The management of machine injuries of the upper limb and hand requires specific and unique methods of treatment. A "reconstructive ladder" of techniques was utilized, ranging from "simple" (e.g., direct closure, skin grafts, and local flaps) to "complex" (free flaps, toe-to-thumb transfer) procedures. The individual procedure selected is the most straightforward, consistent with expediency and early return of a functional hand. The return of these hands to function has been facilitated by recent advances in tissue assessment, free tissue transfer, and skilled hand therapy.

Keywords: Dominant hand, machine injury, band saw, brush cutter, rotator drill.

INTRODUCTION

The hand is a unique fusion of form and function [1]. The hand and wrist are integral components of nearly all human pursuits, including work, leisure, and activities of daily living. This level of involvement makes injuries to these structures common and long-term disability devastating [2]. The hand plays an important role in maintaining body image and a sense of identity as well as serving as an organ of communication among other things [3,4,5]
Hand injuries are common and an increased surge has been seen secondary to the use of machines. Machine injuries to the hand were primarily related to industrial

accidents now are common in civilian people also due to household use of machines. The injuries are caused in non-professionals due to the leisure use of machines. Injuries range from minor lacerations to devastating crush avulsions requiring staged reconstructive procedures in extreme cases severe crush injuries requiring amputation.

Most of the hand injuries are minor in form of lacerations, amounting to about 60 percent of injuries. On the severe side of the spectrum injuries requiring specific interventions include amputations, avulsions, punctures, fractures, crushes, and loss of tissue.

Most of the injuries are caused by human error, neglect of safety precautions, absence of safety mechanisms, and recreational use of equipment. At times errors are caused by distractions and the tendency to grow complacent at work. Repetitive strain is also a common cause of hand injuries, sometimes simple regimen of hand stretches may keep injuries at bay.

MATERIAL AND METHODS

This was a hospital-based single-arm prospective study conducted in the Department of Plastic and Reconstructive Surgery at a Tertiary care hospital in Srinagar. The duration was from 1st January 2019 to 31st December 2022. 46 patients were included. Each record was analyzed as per the etiology, the treatment received, the reconstructive procedures done, the functional and aesthetic outcome, and any postoperative complications and their management.

Inclusion criteria

All patients with machine injuries of the hand, who reported to the Accident and Emergency Department, underwent treatment, and have given consent for the study.

Exclusion criteria

1. Patients with machine injuries involving loss of arms and hands.
2. Patients with a history of surgery or trauma to the same hand.
3. Patients with other life-threatening injuries.
4. Patients with congenital deformities of the hand.
5. Minor injuries requiring no or minor surgical intervention under local anesthesia.

Assessment of Severity.

The severity of all injured hands was assessed by HISS System. (6)It is a descriptive severity scoring system for injuries to the hand, distal to the carpus. The injuries were classified into four grades of increasing severity. The HISS score is grouped into four categories: Minor, Moderate, Severe, or Major Injury, (minor, MHISS <20; moderate, MHISS 21–50; severe, MHISS 51–100; major, MHISS >101).

Observation and Results

Altogether, 46 patients were included in the study, the machines implicated were, wood planer (13 patients), band saw (10 Patients), angle grinder (4 patients), brush cutter (4 Patients), meat mincer (5 patients), machine belt injury (3 patients), rotatory drill (3 patient), hydraulic press (2 Patient), industrial iron (2 Patient).

Most of the affected individuals were young, the mean age of the patients was found to be 23 years ranging from 12 to 55 years. The ages of the patients in this study reflected the highest number of injured individuals within the workforce age bracket of 11–20 years (24%), 21–30 years (43. %), and 31–40 years (20%). Among the injured 39 were males (85%). Hand dominance was recorded in all cases. All the patients in our series were right-handed. The dominant hand (right hand) was more frequently injured 74% (34 cases).

Pattern of injury

The severity of the injury, as well as the incidence of injury, decreased from the radial to ulnar aspect of the hand, with the

most severe injury occurring around the first web space of the hand. The following chart shows that injury severity of injuries and fractures has a decreasing trend from the radial to the ulnar side of the hand. Also, procedures done varies, most of the revascularizations and reimplantations were done on the thumb followed by the index finger. The procedure reflected a pattern of injury as well as efforts made for salvage keeping in view the contribution of the thumb to the function of the hand.

Figure 1: Distribution of trauma and procedures along the digits of the hand.

There was the involvement of the first web space in most of the injuries. The extent of injuries varies depending on the severity of the case. There was a decreasing trend of all patterns of injuries from the radial to the ulnar side.

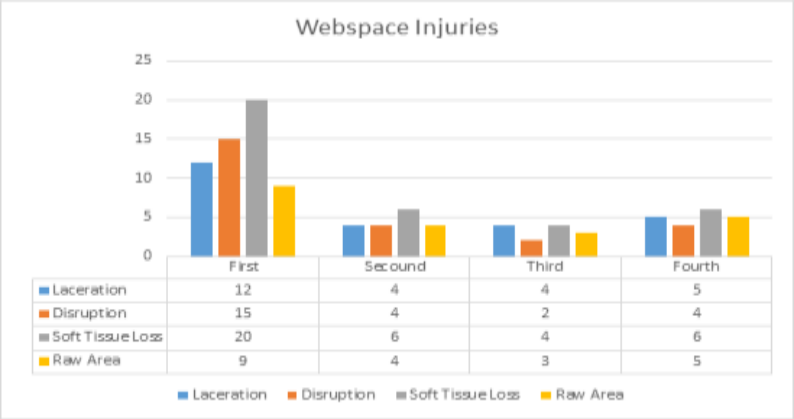

Figure 2: Distribution of injuries along the webspaces of hand

Severity of Injury

The severity of all injured hands was assessed by HISS System. The injuries were classified into four grades of increasing severity, mild (8 cases), moderate (5 cases), severe (14 cases), and major (19 cases). Among the different modes of injury

Surgical management

All of the patients underwent a basic washout, clean, and suturing with 42 patients also undergoing debridement. In total 18 patients had some of the affected areas amputated; this included formalization of traumatic amputations. It is also significant that twelve patients underwent revascularization and four reimplantations. Twelve patients underwent groin flaps as a primary or delayed primary in the same admission. Most of the groin flaps were used around the first webs space. Ten patients required split skin grafting and three STSG for donor defect. Venous grafts were required in four of the revascularization all in primary settings. Two patients were managed with FDMA flap for thumb defect, one patient was managed with reverse radial forearm flap

for compound defect dorsum of thumb, and another with free lateral arm flap for compound defect of thumb. Amputations were needed in fourteen fingers and one hand because of non-salvageable digits or hand respectively. In one case failed revascularization of the thumb and index finger was managed by groin flap cover to cover the exposed bones and make a base for the toe to thumb transfer if the patient consents. (Case 6)

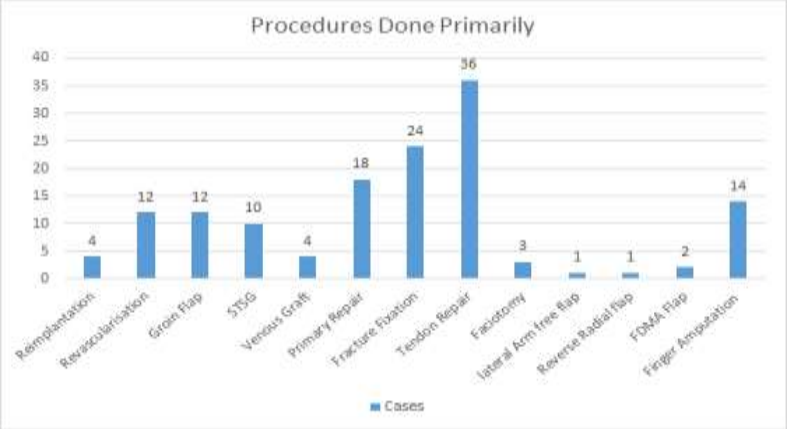

Figure 3: Procedures done primarily or delayed primarily.

Case 1

Machine injury right hand with an avascular thumb with near total amputation and fracture First metacarpal Head and trapezoid. Wound Debridement with K wire fixation of right thumb with Revascularization of right thumb using venous graft was done patient had an excellent outcome on follow-up.

Figure 4: Severe machine injury hand with devascularized thumb

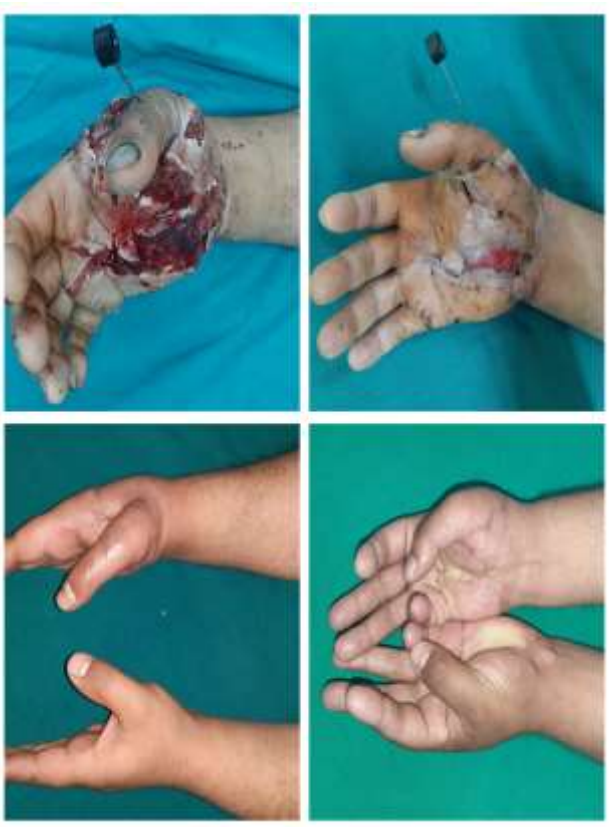

Figure 5: One month (left upper), two month follow-op (right upper), and one year follow-up with excellent functional and cosmetic outcome.

Case 2

Machine injury right hand with amputation of right index finger and loss of soft tissue

dorsum of right hand. Formalization of amputation, debridement of wound with grafting raw area done.

Figure 6: Loss of soft tissue dorsum of hand and amputation or index finger (upper), formalization of amputation with grafting.

Figure 7: Outcome after 6 months

Case 3

Crush injury left thumb with loss of soft tissue and exposed bone FDMA flap planned. Flap well settled and donor site graft stable. FDMA flap chosen over groin flap since it is single stage procedure and no need to restrict shoulder and elbow. Dorsoradial flap was not planned since flap was in zone of trauma.

Figure 8: Post FDMA flap outcome.

Case 4

Machine injury left hand with loss of soft tissue left thenar eminence and exposed tendons managed with K wire fixation and groin flap.

Figure 9: Initial presentation (Upper), muscle injury, exposed first metacarpal head (Right lower), Post groin flap detachment.

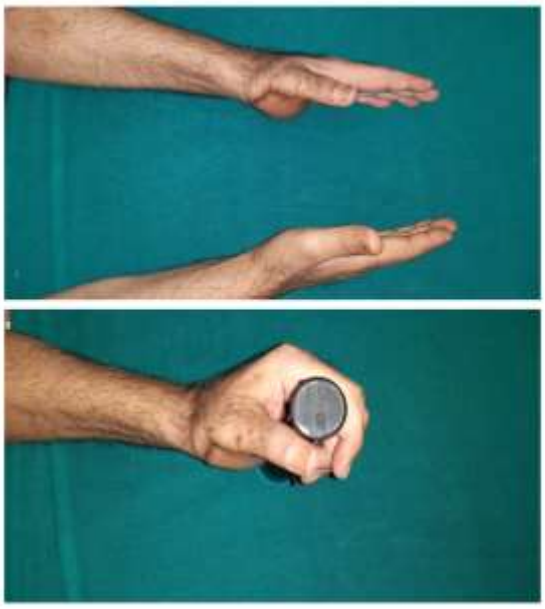

Figure 10: Outcome after 6 months, flap thinning can be done to improve contour.

Case 5

Angle grinder injury left thumb with loss of soft tissue exposed IP joint thumb managed by debridement and reverse radial forearm flap done in primary setting. An interesting point can be noted that hand driven machines usually cause injury to left hand. Since the person usually holds machine in the right hand and object on which he has to work on in left hand so in such scenario left hand is exposed to trauma.

Figure 11: Machine injury left thumb with compound defect after stabilisation of thumb with K wire (Upper), well settled flap with good outcome donor site graft stable (Lower)

Case 6

Band saw injury left hand with amputation of radial side of hand, reimplantation was initially started but given up, and stump was covered with groin flap. Later toe to thump transfer can be planned.

Figure 12: Groin flap over amputation stump.

Case 7

Case of meat grinder injury right hand with multiple fractures loss of soft tissue, laceration dorsum of hand managed by multiple procedures.; Procedure 1 K wire fixation of II III IV MC Right hand; Procedure 2 wound debridement with amputation distal phalanx Right thumb with STSG raw area fingers; Procedure 3 Realise of first web space contracture with STSG; Procedure 4 Realise of first web space contracture with groin flap; Procedure 5 detachment and final in setting of groin flap

Figure 13: Severe injury right hand on reception and after K wire fixation

Figure 14: post fracture stabilization (upper), follow-up post WD with amputation distal phalanx Right thumb with STSG raw area; first web space contracture can be noted (Right lower)

Figure 15: 6 month follow-up post contracture release with STSG (upper), followed by groin flap for first web space with improved outcome. (Right lower)

Case 8

Machine cut injury left first web space with fracture spiral first metacarpal, cut EPL, EPB.

Figure 16: First metacarpal spiral fracture, EPL and EPB cut Exposed MCP Joint

Figure 17: K Wire fixation of 1st metacarpal with repair of EPL and EPB tendons and joint capsule. No need of POP as both MP joint and IP joint stabilized by K wires.

DISCUSSION

An injury to the dominant hand poses immediate functional implications for the motor functions such as eating, writing, buttoning, unbuttoning, picking up things, or applying cosmetics, as well as bilateral hand functions such as tying laces or food preparation. Knowledge of the patient's occupation and hand dominance has a greater impact on the treating therapist/clinician as the patient's occupation will determine the treatment plan, time frames, and treatment modalities to be used in rehabilitation. The therapist has to match the rehabilitation activities to the patient's occupational areas of work, domestic, leisure, and activities of daily living; second, the patient's hand dominance, diagnosis, and aim of treatment will affect the type of activity, and the structuring of the treatment activity and area, i.e. placement of equipment, tools, and materials.

.All of our patients needed debridement with thorough cleaning and washing of wounds. In some patients single operative procedure was done while second-look surgery in the same admission was done in 30 patients. Delayed reconstructive procedures were done in 12 patients in our series.

In total 34.7% of the patients had some affected areas amputated; this included formalization of traumatic amputations. It is also significant that about 26 % of patients underwent revascularization of any finger, 26% required groin flap cover and 21.7 % required split skin grafts in the primary setting.

Joint dislocations and bony injuries were managed with K-wire fixation in all cases. Open Reduction and Internal Fixation (ORIF) of bony injuries, were not done. Minor wounds healed with secondary intention again with minimal resultant contractures. Near normal range of motion of the affected digits was obtained after intensive physiotherapy. No patient in this injury category required any other surgical procedure for stiffness in the rehabilitation phase.

Groin flaps were used for adequate wound coverage mainly in the primary or delayed primary setting. The groin flap was the most favoured in our series as the donor site was hidden and vessels were spared for any future microvascular reconstruction. The posterior interosseous artery and the reverse radial flap are the other flaps that can be used in the reconstruction process. (7) Though their use has not been done because of diffuse injury to the hand that would result in doubtful collateral and reverse circulation. Although reverse radial forearm was done in one case in isolated trauma thumb with intact collateral circulation. (Case 5)

Revascularization and replantation in the acute setting were feasible options in our opinion despite the extensive nature of the injuries. Among the 46 patients described 12 revascularizations and four reimplantations have been done, all in acute settings with a good outcomes. The favourable outcome in the case series can be attributed to multiple factors, including that

most of the injuries were isolated hand injuries, caused by machines of small-scale industries mostly wooden joinery mills and furniture outlets. Other factors may be procedures being performed regularly with the availability of fine microvascular instruments and a very good quality operative microscope. Four patients among the twelve had underwent venous grafting during the revascularization procedure and had no adverse outcomes due to the procedure. The graft was harvested from the same limb beyond the trauma zone in all cases.

Formalization of amputations was done in fourteen cases in our series, these were the cases in which the amputated parts were severely crushed and not amenable to reimplantation or revascularization. The level of amputation varied in different cases. Early amputation of severely injured parts prevents the morbidity associated with multiple failed attempts at reconstruction. Early amputation is preferable to protracted attempts at reconstruction. In the hand, primary amputation should also be considered mainly for injuries combining a single digit with a comminuted articular fracture and a combination of tendon and nerve. In these cases, reconstruction of the injured part offers little hope of useful restoration of function.

Rehabilitation

The operated cases of machine injury hand needed extensive rehabilitation. The rehabilitation was programmed specifically for every patient depending on the injury and operative procedures done. The rehabilitation was supervised by the operative surgeon and the physiotherapist the target being, achieving the range of motion, strength, prevention of deformity, and prevention of contractures.

All of the patients were referred for rehabilitation at some stage of their follow-up. Of this total, 34.7% never attended rehabilitation.17.4 % of patients attend few sessions and 26. % (12 patients) were very particular about physiotherapy and these were the patient with a good outcome for their grade of injury.

CONCLUSION

The management of machine injuries of the upper limb and hand requires specific and unique methods of treatment. The basic principle is to dispose of unhealthy tissues to minimize the risk of infection before embarking on reconstruction, where possible. Consideration of all of the above-mentioned variables is required before deciding on the reconstructive procedure.

A "reconstructive ladder" of techniques was utilized, ranging from "simple" (e.g., direct closure, skin grafts, and local flaps) to "complex" (free flaps, toe-to-thumb transfer). The individual procedure selected is the most straightforward, consistent with expediency and early return of a functional hand. The return of these hands to function has been facilitated by recent advances in tissue assessment, free tissue transfer, and skilled hand therapy.

Groin flap was frequently utilized for the cover of compound defect hand and in case of soft tissue loss in primary or delayed primary settings. The use of local flaps was not done to avoid flaps from the zone of trauma and to avoid any compromise of the vasculature.

The outcome of reimplantation and revascularization was quite encouraging, so formalization of amputations should not be the predominant course of action. Primary closure was possible and done in some cases without any adverse outcome since most traumas were sharp cuts with minimal loss of tissue

Stiffness was common after surgical intervention and immobilization of the hand and can be countered by a properly instituted range of motion exercise program instituted as early as possible. This might not be possible in hands fixed with K-wires and patients requiring prolonged splintage. At times the outcome in some cases was decided by the patient's compliance with the physiotherapy program.

Declaration by Authors

Ethical Approval: The study was approved by the Institutional Ethics Committee

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Conflict of Interest: The authors declare no conflict of interest.

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