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Original Research Article

Agriculture related traumatic hand injuries and reconstructive interventions: an observational study at a tertiary care centre

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ABSTRACT

Background: India contributes 10% (225 million) to global agricultural workforce, where hand injuries are frequent and major health related problem and economically significant issues. Farming has fatality rate over five times higher than other sectors. Risk factors include poor ergonomics, lack of safety awareness, and environmental hazards. Aim was to study agriculture related traumatic hand injuries and reconstructive intervention, and to educate surgeon on importance of sophisticated surgical care and aggressive physiotherapy in rehabilitating patients to early hand function.
Methods: This prospective observational study of 3 years conducted at KVV hospital, Karad. Structured proforma was completed for 386 patients presenting with agriculture-related hand and wrist injuries distal to wrist. Data on demographics, injury type, hand dominance and seasonal trends were studied.
Results: Males were more frequently impacted than females belonged to age group of 31 to 45 with right-handed dominance along with injury caused by hand tools (63.47%) and sugarcane machine (48.70%), most frequently occurred in October month with majority of lacerated wounds (41%) correlating with peak harvesting season. Common causes include entanglement in machinery and traditional tools, leading to amputations and fractures.
Conclusions: Farm equipment causing injury is major health issue. It needs educating farmers, prohibiting children from entering areas with agricultural machinery, disseminating information about agricultural accidents and how to prevent them, and modifying working hours of farming staff. This study focuses on type and severity of hand injuries in agriculture and emphasizes need for systematic assessment to guide effective treatment and prevention.

Keywords: Hand injury, Agricultural hand tools, Surgical interventions, Hand reconstructive surgery

INTRODUCTION

India accounts around 10% (225 million) of global agricultural labour.[1] Human hands play an important role in our professional lives. Hand injuries are significant contributor to accident and have a large economic impact since they can hinder career opportunities.[2] Severity and violence reflect occupational dangers of agriculture sector higher than any other sector. Farming's fatality rate is more than five times that of all other occupations.[3] Most common injury induced by entanglement in farm machinery include traumatic amputation of fingers and high intensity compound fracture of hand.[4-6] According to Karthikeyan et al traditional agricultural tools and equipment are typically made locally from materials such as wood, iron, or stone.[7]

Farm equipment can inflict catastrophic injuries such as lacerations, amputations, fractures, and crush injuries to hand. Although there are modern changes, classic hand tools such as spade or hoe, sickle, hammer, shovel, knife, etc. have been used. According to Murphy, farming is skill-based occupation requiring complex and repeated tasks.[8,9] Injury may result from lack of ergonomic

considerations in design of hand tools and equipment, inexperience, ignorance of safety precautions, farmer neglect, and unfavourable environmental conditions that often end in permanent impairment.[10,11] Nag separated farming accidents into farm implement-related agricultural accidents that involves use of hand tools or farming machinery, while nonfarm implement-related agricultural accidents involve other factors such as snake bites, hazardous fuels, airborne irritants, noises, vibrations, zoonoses, dusts, chemicals, fungal, endotoxins, carrying heavy loads, exposure to heat, falls from heights, and electrical hazards.[1] Objective assessment of hand injuries is difficult and challenging topic. Current study focuses solely on hand injuries, which vary in kind and severity according to tissue damage involved.[13]

The study objectives were to analyse incidence, mechanisms, and patterns of hand injuries sustained in agricultural sector, and to assesses types and outcomes of reconstructive procedures performed along with importance of precise surgical planning, advanced reconstructive techniques, and early intervention in optimizing patient outcomes. It focuses to educate surgeons on implementing structured, aggressive postoperative physiotherapy protocols to enhance mobility, prevent stiffness, and restore early hand function as well as promote multidisciplinary approach involving surgeons, physiotherapists, and occupational therapists for comprehensive rehabilitation and reintegration into daily and occupational activities.

METHODS

This prospective observational study was conducted at KHMRC Hospital, KVV Karad, Maharashtra. Structured proforma for hand injuries was completed by operating surgeon. Total of 386 patients presented with agriculture-related hand and wrist injuries to emergency department between 01 January 2022, and 31 December 2024, were included. Study focused on cases with injuries distal to wrist. Exclusion criteria comprised patients with severe illness, coma, sepsis, multi-organ failure, pre-intervention mortality, lack of assessment by general or plastic surgery teams, and proximal injuries in same limb. Fractures were not categorized as open or closed.

Detailed history was obtained for each patient. All patients underwent thorough general and local examinations to assess extent of injury and determine need for surgical intervention. Injury assessment included evaluation of skin, soft tissue, tendons, nerves, blood vessels, and bones, along with distal part viability and presence of wound contamination. Laboratory investigations, hand X-rays, and Doppler studies were conducted in cases of suspected vascular injury. Wound cleaning and debridement were performed under anesthesia. Fractures were appropriately reduced, and soft tissue repairs were carried out according to nature and extent of damage. Affected limb was kept elevated. Infected wounds were drained, and pus samples were sent for culture and sensitivity testing. Daily saline dressings were applied, and patients were evaluated on alternate days.

Data were collected on each patient demographics with hand dominance profile, mode of injury, type of injury along with machine, spatial distribution across study period, types of surgical procedures along with complications and residual deformity. Photographic record of injury and subsequent repair process was maintained. Institutional Ethical Committee approval was obtained for the study.

Statistical tool

Data entry, interpretation and analysis done by statistical package for the social sciences (SPSS) version 30 and Microsoft Excel (MS Excel). Descriptive statistics were noted. Study's observation has been presented as tabular form, diagrammatically and as percentages.

RESULTS

A total of 386 patients with agriculture-related hand injuries were included in study. Majority belonged to 31–45 years age group 148 (38.34%), followed by 16–30 years 93 (24.09%) and 46–60 years 74 (19.17%). Adolescent cases <15 years constituted 29 (7.51%), and those above 60 years made up 42 (10.88%) of total cases. In terms of gender distribution, 313 (81.09%) were male, whereas 73 (18.91%) were female (Table 1). Regarding handedness, 348 (90.16%) involved right hand, while 38 (9.84%) involved left hand. Also indicates occurrence of injuries with strong seasonal variation, 225 (58.29%) of cases reported between October and December, correlating with peak harvesting season. Lowest incidence was recorded between January and March 36 (9.33%). Figure 1 shows most common mode of injury was accidental hand tool injury during agricultural activities. Figure 2 shows among machinery implicated, sugarcane machine was leading cause, followed by tractor crush injuries, chaff cutters, coir machines, and hand pumps. Figure 3 indicates injuries ranged from lacerations (41%) and crush injuries to amputations, degloving, and skeletal or neurovascular damage. Majority were complex injuries requiring surgical intervention. Table 2 indicates wide range of procedures were performed. Under general procedures, most common were wound debridement 234 (60.62%), K-wire fixation 172 (44.56%), and primary skin suturing 114 (29.53%). Reconstructive procedures included tendon repair 156 (40.41%), thenar flap 89 (23.06%), and nerve repair 45 (11.66%). More complex flaps such as groin flap, Moberg, cross-finger flaps were also used in selected cases. Table 3 indicates on follow-up, most common residual deformity was digit loss 42 (10.88%), followed by skin contracture 27 (6.99%), nerve entrapment 32 (8.29%), fracture malunion 23 (5.96%), stiffness 16 (4.15%), and joint instability 15 (3.89%). Figures 4 and 5 showing thenar flap, groin, and thumb reconstructive surgeries, Figure 6 showing K wire fixation and flexor tendon repair to index finger and Figure 7 showing split thickness skin graft.

Table 1: Demographic profile and seasonal distribution.

Category	No. of cases	Total (%)
Age group (years)		
<15	29	7.51
16–30	93	24.09
31–45	148	38.34
46–60	74	19.17
>60	42	10.88
Gender		
Male	313	81.09
Female	73	18.91
Dominance of hand		
Right	348	90.16
Left	38	9.84
Duration		
January–March	36	9.33
April–June	55	14.25
July–September	70	18.14
October–December	225	58.29
Total	386	100

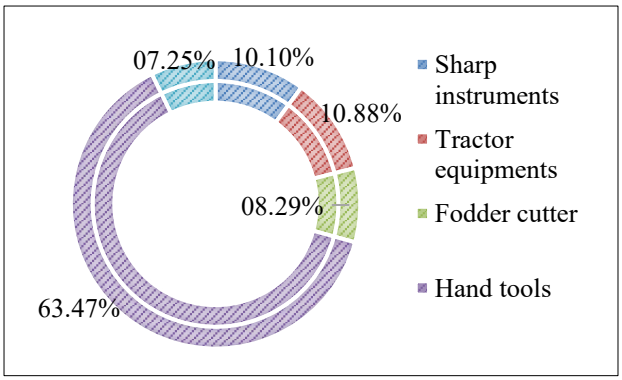

Figure 1: Distribution of mode of injury.

Table 2: Type of surgical interventions and reconstructive procedures.

Surgical interventions	No. of cases	Total (%)
General procedures		
Skin grafting	57	14.77
Shortening and closure	98	25.39
Wound debridement	234	60.62
Primary skin suturing	114	29.53
Revision amputation	35	09.07
K wire fixation	172	44.56
Reconstructive procedures		
Tendon repair	156	40.41
Nerve repair	45	11.66
Cross finger flap	34	08.81
Groin flap	12	03.11
Moberg flap	20	05.18
Thenar flap	89	23.06

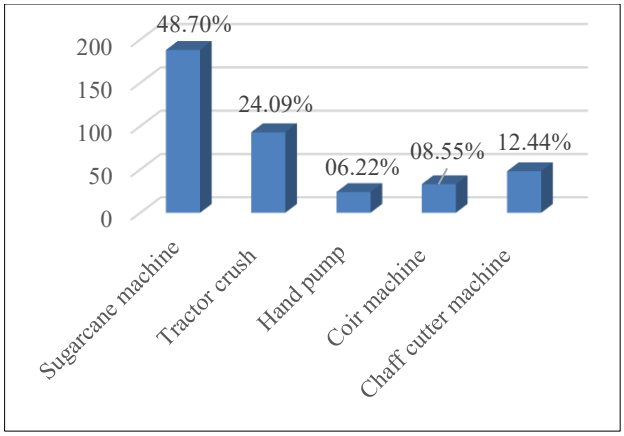

Figure 2: Distribution according to type of machine injury.

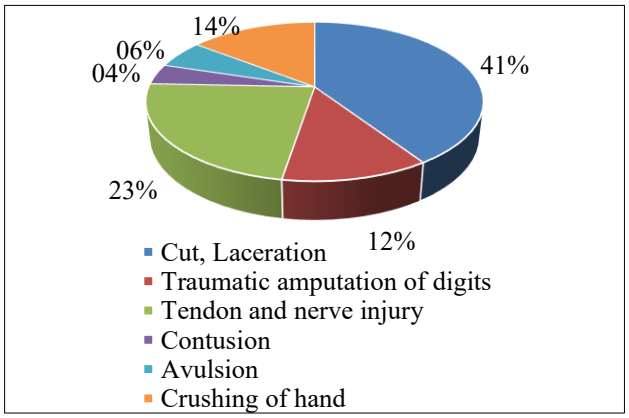

Figure 3: Distribution according to type of injury.

Table 3: Distribution of postsurgical residual deformity.

Residual deformity	No of cases	Total (%)
Stiffness	16	04.15
Digits loss	42	10.88
Skin contracture	27	06.99
Joint instability	15	03.89
Fracture malunion	23	05.96
Nerve entrapment	32	08.29

Figure 4 (A and B): Thenar flap reconstructive surgery.

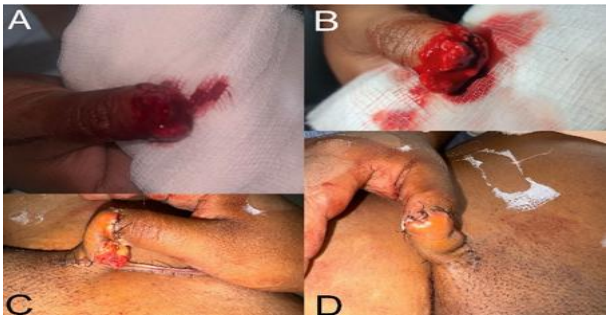

Figure 5: (A-D) Groin flap to right hand thumb.

Figure 6: (A-D) K wire fixation and flexor tendon repair to index finger.

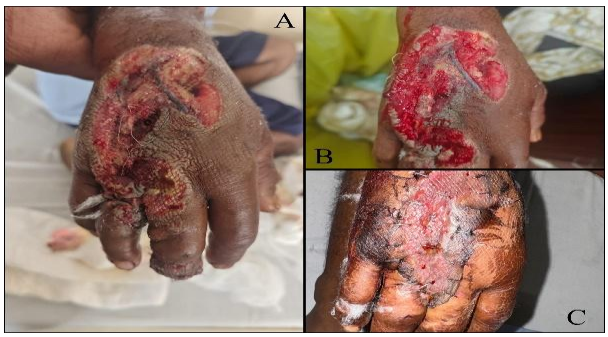

Figure 7: (A-C) Split thickness skin graft.

DISCUSSION

India, with its estimated 640,000 villages, engages substantial proportion of global agricultural workforce, employing over 10% (225 million) of agricultural labour worldwide. The rural agricultural economy is supported predominantly by sharecroppers, tenant farmers, and landless labourers, who together constitute core workforce engaged in diverse crop and allied activities. Crop production in India encompasses a broad spectrum of labour-intensive tasks, including seedbed preparation, sowing, transplanting, weeding, harvesting, threshing, and post-harvest processing. Farmers and agricultural workers are also involved in livestock management, material handling, machinery and tool operation and maintenance, fertilizer, and pesticide application, as well as water lifting and irrigation, storage, and transportation of produce. These activities expose workers to a multitude of potential hazards.[12]

Hand injuries in agricultural settings may result from direct contact with tools, machinery, animals, crops, hazardous chemicals, or harsh environmental conditions. Common implements and machines — including spades, sickles, tractors, diesel engines, bullock carts, chaff cutters, and threshers — pose a significant risk to operators. Injuries sustained can range from minor lacerations to severe crush injuries and traumatic amputations. Notably, agricultural hand injuries do not discriminate by age, often affecting both younger and older family members who contribute to farm work.[14] Seasonal and often time-sensitive nature of agricultural operations — particularly during harvest — imposes long working hours under considerable physical and psychological strain. Extended working periods may lead to fatigue, inattentiveness, and risk-taking behaviour, which in turn heightens likelihood of serious injuries.[15] Hence, cumulative effects of physical exhaustion and a demanding work environment make farming one of the most hazardous occupations, underlining need for improved safety protocols, proper training, and preventive measures to reduce burden of hand injuries in this vital sector.

In our study comprising 386 cases, demographic profile revealed pronounced male preponderance, with 313 (81.09%) male patients and 73 (18.91%) female patients. These findings align closely with other regional observations, underscoring predominantly male composition of agricultural workforce. For instance, Shrihari et al reported that 379 (85.75%) of their cases were male and 63 (14.25%) were female, while Ravikumar et al documented 184 (83.64%) male and 36 (16.36%) female patients among a series of 220 cases.[16,17] Similarly, Rohini et al also noted a significant male predominance 260 (62%).[18]

With respect to age distribution, most patients in our study were of working age, which reflects demographics of those involved in physically demanding farm work. Most cases were clustered within 16–45-year age 241 (62.43%). This is consistent with other reports in literature for example, Shrihari et al observed that 209 (47.29%) of their patients were aged 16–30 years, and Ravikumar et al noted a substantial proportion 158 (71.82%) aged 21–50 years.[16,17] These findings highlight significant representation of middle-aged adults in agricultural labour, especially in sugarcane harvesting and related tasks, where intense manual work, operating farm machinery, and handling sharp agricultural tools are commonplace. This age and gender distribution underscores socio-economic reality that economically active, able-bodied men in these rural communities bear the greatest burden of agricultural labour. Given their extensive involvement in farm operations often under strenuous conditions and for extended hours this group is especially vulnerable to traumatic hand injuries.

In our study, substantial proportion of cases over 90% involved right hand, reflecting marked predominance of injuries to dominant hand. This is consistent with observations from other regional and national studies. Shrihari et al also noted 433 (97.96%) of injuries affecting dominant hand, and Rohini et al similarly reported that 346 (90.93%) of injuries involved right hand.[16,18] This pattern is readily explained by greater reliance on dominant hand in performing most agricultural and manual tasks, increasing its exposure to mechanical trauma.

Furthermore, hand tools in 245 cases (63.47%) emerged as leading cause of injury across these agricultural populations. Our findings align with those of Devendra et al, who reported that 258 (74.72%) of hand injuries occurred during of farm tools, as well as those of Nayanabai et al who documented 61 (58.6%) incidences of hand injuries during similar activities.[19,20] The consistency of these findings underscores high-risk environment faced by agricultural workers that involve farm tools and heavy manual labour. These patterns are observed not only in India but also across similar agricultural contexts in neighbouring countries like Nepal, where comparable demographic structures, farming practices, and working conditions prevail.

Our study was conducted in remote, predominantly agricultural region where sugarcane cultivation forms backbone of local economy. Given seasonal nature of sugarcane harvesting, we observed significant spike in hand injuries during last quarter of year, which coincides with peak harvest season. 188 (48.70%) of cases sustained injuries related to sugarcane machines, followed by 93 (24.09%) who sustained tractor-crush injuries. This pattern underscores close relationship between agricultural work cycles and risk of trauma, as manual and mechanical processes intensify during harvest period. By contrast, study conducted by Ravikumar et al in different region found paddy machines to be more common cause of agricultural hand injuries, reflecting local crop profile and associated agricultural practices.[17] This further emphasizes that specific type of agricultural machinery in use directly influences injury profile seen in each geographical area. With respect to mode of injuries sustained, lacerated wounds were most prevalent in our study, accounting for 157 (41%) of cases, followed by tendon injuries 89 (23%) and crushing injuries 56 (14.51%). These findings are similar to those reported by Mustafa et al, who noted that 208 (55.60%) of injuries were lacerations, with crushing of fingers present in 71 (19%) of their patients.[21] In contrast, Shrihari et al observed that crushing injuries were most common mode of trauma, accounting for 295 (66.74%) of their cases.[16]

Our study findings suggest that management of agricultural hand injuries often require multidisciplinary surgical approach, where general plastic surgery principles are frequently combined with specialized reconstructive techniques. In most cases, surgical strategy included thorough wound debridement followed by staged closure and reconstruction, tailored to complexity and severity of each injury. Similar observations were made by Ravikumar et al, who emphasized that effective wound management often necessitated multiple debridement and sequential closures to control contamination, preserve viable tissues, and optimize wound bed for definitive repair.[17] Proper management includes immediate stabilization, potential blood transfusion, thorough wound care.[18,19]

Additionally, Prasad et al reported that 116 (27.68%) cases involved shortening of injured digits with primary closure or delayed wound closure, underscoring need to balance functional preservation with sound wound healing.[19] These findings highlight that management of agricultural hand trauma is rarely a single-stage procedure. Instead, it typically requires a combination of surgical decontamination, tissue repair, wound bed optimization, and in some cases, revision surgery to achieve stable soft-tissue coverage, functional restoration, and acceptable cosmetic outcomes. Overall, this underscore's important role of plastic and reconstructive surgery in trauma care, especially in rural agricultural settings where wound contamination is common, and injuries tend to be complex. Early and staged interventions, conducted according to principles of plastic surgery, not only improve wound healing but also enhance functional recovery of patients, facilitating their early return to agricultural work.

Residual deformities were observed in substantial proportion of patients during follow-up. Most common residual deformity was digit loss seen in 42 (10.88%) cases, followed by nerve entrapment in 32 (8.29%) and skin contracture in 27 (6.99%). Other sequelae included fracture malunion 23 (5.96%), stiffness 16 (4.15%), and joint instability 15 (3.89%). Our findings are consistent with those of Rohini et al documented a high incidence of loss of digits 109 (26%) and stiffness 67 (16%) after primary wound management and repair, especially in patients presenting with crush and degloving injuries.[18,19] Ravikumar et al studied wound infection was most common observed affecting 42 (10.88%), partial flap necrosis documented in 2 (0.5%), stiffness in hand and fingers affecting 29 (7.5%).[17] This underscores importance of early mobilization, patient compliance, and structured physiotherapy protocols. Prolonged immobilization, delayed referral, and inadequate postoperative rehabilitation are key contributors to joint contractures and reduced range of motion. Relatively high rate of digit loss and nerve entrapment may reflect severity of primary injuries sustained, often due to entrapment in powered farm machinery like sugarcane and chaff cutters.

Overall, findings emphasize that prevention and management of complications in agricultural hand injuries require a multidisciplinary approach. To mitigate these risks, timely and meticulous surgical intervention, including thorough debridement, stabilization, and appropriate soft-tissue or reconstructive procedures, infection and underlying precipitating diseases to be taken

care of is pivotal.[20,21] Equally important is initiation of structured and aggressive postoperative physiotherapy, tailored to patient's specific injury and functional needs.[22,23] Early mobilization, conducted under supervision of trained therapists is essential for preserving joint range of motion, promoting tendon gliding, and minimizing scar contracture early debridement, proper soft tissue coverage, and aggressive rehabilitation are critical components of care. Strengthening awareness regarding first-aid practices among farmers, improving access to tertiary care, and timely surgical intervention can substantially reduce morbidity in this vulnerable population.

Limitations

Being single-centre observational study, findings may not be generalisable to other regions with different agricultural practices. Data predominantly represent cases referred to tertiary care facility. Follow-up was inconsistent in some patients, restricting comprehensive assessment of long-term functional outcomes, return to work, and quality of life. Additionally, study did not account for socioeconomic or educational factors that could influence both injury occurrence and rehabilitation.

CONCLUSION

Prompt and aggressive management of hand injuries is crucial for achieving optimal functional outcomes, especially in context of agricultural trauma, where complex soft-tissue and osteotendinous injuries are common. These injuries have high propensity for complications due to contamination, delayed presentation, and the nature of the trauma. Delays in definitive surgical intervention can lead to infection, tissue loss, scarring, stiffness, joint contracture, severely impair hand mobility, strength, and dexterity, resulting in long-term disability and a significant economic and social burden for the patient. A multidisciplinary approach, combining skilled surgical technique with early rehabilitative therapy, enhances tissue recovery, restores hand function, and improves long term outcomes.

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