



## SUGARCANE CRUSHING MACHINE INJURIES-MECHANISM OF INJURY, CLASSIFICATION & MANAGEMENT.

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**SUMMARY:** Sugarcane crushing machine injuries are common throughout India. Based on the observation on 53 sugarcane machine injuries to the hand over a period of 2 years, the mechanism of injury has been elucidated. A classification has been proposed and treatment guidelines have been given.

### INTRODUCTION

Sugarcane crushing machine injuries are seen only in India and are not discussed in any standard text books<sup>1</sup>. These injuries have a characteristic pattern recognizable of the trauma caused by the serrated steel rollers of this machine. Apart from these power rollers, atypical injuries can be caused by the open gears and the drive-belt of the machine. We have studied fifty typical and three atypical injuries and followed them for 2 years.

The typical clinical features of these injuries are as follows:

**1. Area proximal to the level of the thumb is never injured.**

The injury occurs only distal to the level of the thumb. This is because the thumb is abducted while feeding the sugarcane into the rollers. The thumb

abuts over the guard and prevents the hand from being drawn in any further.

**2. The thumb is rarely injured.**

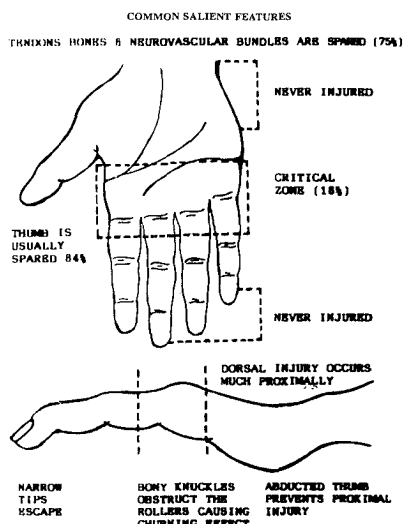
The thumb is spared in over 84% cases and even when injured it has only skin lacerations or cuts.

**3. The finger tips are never injured.**

The soft pulp is easily compressed and passes uninjured through the rollers. The pulp or the nail bed may only be contused.

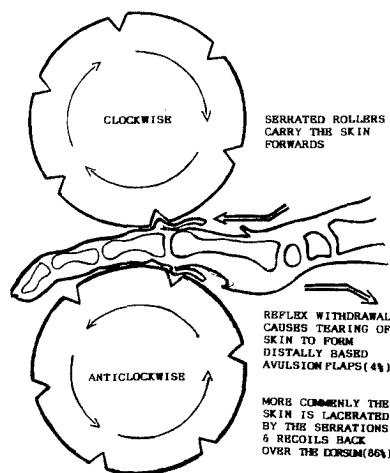
**4. There is a critical zone of maximum injury.**

The critical zone of maximum injury where damage to neurovascular bundle occurs is between the distal palmer crease and the proximal interphalangeal joint crease. Damage to the neurovascular bundles needs to be checked in this particular region. Severe injury occurs in this zone

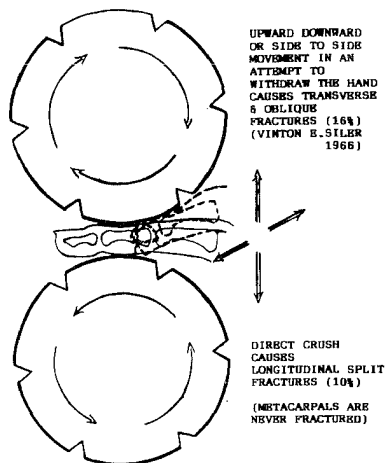


(Fig-1)

MECHANISM OF DISTALLY BASED AVULSION FLAPS

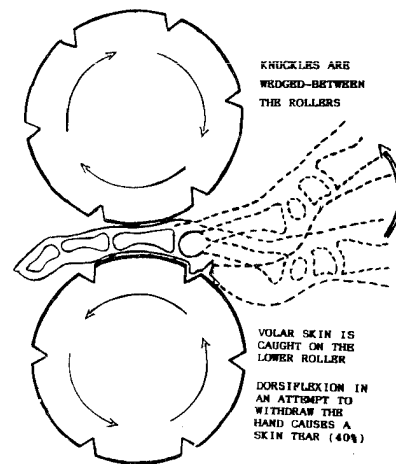


(Fig-2)

MECHANISM OF TRANSVERSE OBLIQUE  
& LONGITUDINAL FRACTURES

(Fig-3)

MECHANISM OF TRANSVERSE PALMAR TEAR



(Fig-4)

because the knuckles get caught between the rollers and obstruct the hand from going any further. During this time the lower roller keeps rotating against the same skin area causing a churning effect and creating maximum damage.

#### 5. Tendons, bones and neurovascular bundles are not always injured.

Tendons, bones and neurovascular bundles are spared in 75% of the cases. This is because the serrated rollers do not interdigitate. There is a gap of 3-15mm in between the rollers. Thus they do not cause a complete crush. The gap is adjusted every time to extract maximum juice. Severe injuries occur when the rollers are 3-9mm apart and only minor injuries occur when the distance is 10mm or more. This can be correlated with average thickness of an adult finger being 10-12mm (direct measurement in patients).

Patients with severe injury show 3-4mm multiple longitudinal skin lacerations which correspond to the serrations on the rollers. Apart from these common features the injury can present as transverse palmar tear, distally based avulsion flaps or fractured phalanges. These result from three different forces.

#### THE MECHANISM OF INJURY

The forces acting are

- Compression, depending on the distance between the rollers.
- Forward traction caused by the rotation of the rollers.

- The patient adds to his own injury by reflex withdrawal of the hand providing a force in the opposite direction. This force is further compounded if there are jerky up and down or side to side movements in an attempt to pull the hand out (Fig.2). These twists cause transverse and oblique fractures (16%) (Fig.3). Whereas longitudinal split fractures due to direct crushing occur only in 8-10% cases, it should be noted that the metacarpals are never fractured.

Transverse palmar skin tears and distally based avulsion flaps also occur due to forceful attempts at withdrawal of the hand caught between the rollers (Fig.2&4). It is also seen that mobile dorsal skin gets easily carried into the rollers and recoils back into place after the injury. It shows a level of injury much proximal (Fig.5). However, the entire hand is not carried into the rollers upto this level. Etin<sup>2</sup> studied experimental roller injuries created in anaesthetized animals. He described various forces but in the anaesthetized animals there was no force of reflex withdrawal. Thus he did not get the same clinical pattern.

Reversing of the rollers in order to deliver the injured hand causes an additional crush on the way out and results in a severe injury. The best way to release the injured hand is to loosen the rollers and remove it gently. Accordingly a list of safety precautions (Fig.6) has been given to all the stall owners and the municipal authorities within the city of Mumbai as a measure of prevention.

**CLASSIFICATION**

Few classifications exist for similar injuries.<sup>3</sup> We have proposed the following classification for the sugar cane crush injuries.

- Minor injury - abrasions or lacerations of the skin only, with no injury to the deeper structures.
- Moderate injury - Skin lacerations with denuded or lacerated tendons or fractures.
- Severe injury - In addition to the above skin avulsion, loss of skin, degloved flaps or injury to the neurovascular bundle.

**MANAGEMENT**

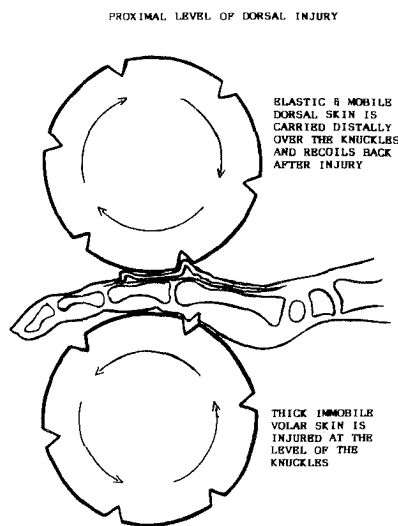
Management of minor injuries is like any other hand injury with suturing, rest and elevation. These injuries always recover well.

In moderate injuries the longitudinal frayed tendon fibres are trimmed to smoothen the surface. Cut tendons are repaired with a modified Kessler's stitch. The volar laceration is closed and the dorsal cut is allowed to gape<sup>4</sup>. This is not closed under tension but covered with split skin. Rest in functional position and elevation is given with Kleinert's traction for tendon repair. Comminuted and longitudinal split fractures are held by traction on a halo splint<sup>5</sup>. Severe injuries are cleaned and subjected to a conservative debridement, dressed with 1% xylocaine packs, saline gauze, well padded dressing and rest on a halo splint. The MP joints

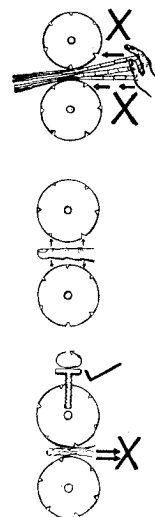
are rested at seventy degrees and not at an acute ninety degrees. It is difficult to decide the extent of tissue damage at initial evaluation. The wound is reassessed every 48 hours and serial debridement is carried out with delayed skin grafting as required. Flaps are strictly reserved only for exposed joints, tendons, bones or neurovascular bundles<sup>6</sup>. Primary flaps are not preferred. Disadvantages of flaps are as follows:

1. Margins of the crushed tissues suffer progressive thrombosis and venous occlusion. A primary flap may be inadequate and get sutured to tissues of doubtful viability.
2. A flap interferes with giving elevation, giving padded compression dressing, functional position and proper immobilization of fractures.
3. Due to a flap, physiotherapy is delayed for 4-6 weeks and a bulky, insensate flap discourages use of the reconstructed hand. We prefer to start physiotherapy by the end of second week.

Transverse palmar tears or distally based avulsion flaps may present at the level of the distal palmar crease. This is the critical zone of maximum trauma caused by the churning effect of the lower rollers. Damage to neurovascular bundles occurs in this zone. The critical zone extends between the distal palmar crease and the PIP joint crease. The bed also is churned and devitalized. Serial debridement and reassessment is required. At least half of the distally based avulsion flaps necrose and a split skin graft can be used by day five. As mentioned earlier a flap is used only for specific indications. Avulsion flaps on the dorsum or even multiple



(Fig-5)



- CAUTION**
- HAND MAY GET ACCIDENTALLY ENTRAPPED IN A SUGARCANE CRUSHING MACHINE AND BECOME SERIOUSLY DISABLED.
1. DO NOT CLEAN THE MACHINE WHILE IN MOTION.
  2. DO NOT PUSH THE SUGARCANE INSIDE WITH YOUR HANDS.
  3. KEEP THE ROLLERS LOOSE AND KEEP THE DISTANCE BETWEEN THE ROLLERS TO MORE THAN ONE FINGER'S BREADTH.
  4. IF YOUR HAND IS CAUGHT, STOP THE MACHINE AND LOOSEN THE ROLLERS TO REMOVE YOUR HAND.
- DO NOT REVERSE THE MACHINE.
- DO NOT PULL THE HAND OUT FORCIBLY. THIS CAUSES ADDITIONAL INJURY.

(Fig-6)

devitalized 3-4mm strips of lacerated skin on the dorsum do well with excision and skin grafting, because here only the mobile skin is carried into the rollers and recoils back after injury. The wound bed is not crushed or devitalized.

## RESULTS

Early complications were loss of graft (16%) and partial or complete finger amputations (10%). Infection responded to local wound care and there was no osteomyelitis. Late complications were finger contractures, web contractures, IP and MP joint capsular contractures, and stiffness (40%). This study of fifty typical and three atypical cases followed for 2 years included 16% minor injuries, 54% moderate injuries and 30% severe injuries. Cases of severe injury had to undergo five to eight secondary procedures before achieving good function.

Composite function of all finger joints was measured by Kleinert's criteria as pulp to palm distance on complete flexion. (5-10mm is excellent and 11-15mm is good, 16-30mm fair & more than 30mm is poor). Gross function was evaluated by pinch and grasp. 50% cases had excellent to good function as per Kleinert's criteria<sup>7</sup> and 30% had fair results and 20% had poor results. While 74% cases had good recovery of gross function with 22% having fair results, the cases which had partial or complete amputation of one or more fingers comprised the group of poor results<sup>8</sup>.

## DISCUSSION

The mechanism of injury to the hand in the sugarcane crushing machine has been elucidated and a classification has been proposed and treatment guidelines have been given. Since crushed tissues show progressive necrosis, reassessment is often required. Delayed skin grafts

are preferred and flaps are used over exposed joints, bones, tendons or neurovascular bundles. A hallow splint is used for fractures. Distally placed avulsion flaps should not be sutured back since at least 50% of them necrosed in the first 5 days. Longitudinal lacerations on the fingers are closed primarily on the volar side and skin grafted on the dorsum. A list of precautions to be taken for prevention of this injuries was given to the stall owners and municipal authorities in Mumbai.

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