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RESEARCH PAPER

Functional outcome of the delayed primary and early secondary repair of Zone V flexor tendon injury of the hand

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Background and aims: *The function of the hand and fingers is related to the normal integrity of the bones, tendons and neurovascular structures. Tendon injury often requires immediate repair. The present study was undertaken to assess the functional outcome of flexor tendon injury following delayed primary and early secondary repair of the hand's Zone V flexor tendon injury.* ***Methods***: *In this prospective clinical study, all patients having flexor tendon injury in zone V of hand that was operated in the Department of Plastic and Reconstructive Surgery, Gauhati Medical College and Hospital, Guwahati from January 2014 to August 2019 were included. All the cases were repaired by the modified Kessler method, and standard early postoperative physiotherapy using Kleinert protocol was used. Total active motion percentage (TAM) of individual fingers as per The American Society for Surgery of Hand (ASSH) protocol was calculated. Hand activities were assessed according to patient satisfaction.* ***Results***: *A total of 155 patients with zone V flexor tendon injuries were evaluated. The age at injury ranged from 9 to 62 years. The most frequent mechanism of injury was accidental injury. Delayed primary repair was performed in 58.1% of patients and early secondary repairs in 41.9% of patients. The best TAM was found in the index finger (186.9) and worst in the ring finger (175.8). Ball compression activity had the best satisfactory outcome (83.9%).* ***Conclusions:*** *Tendon repair has a better outcome with delayed primary repair than early secondary repair, according to TAM. Postoperative early mobilization results in the satisfactory outcome of the hand activities.*

Keywords: *Flexor tendon injury, Delayed Primary Repair, Early Secondary Repair, Total active motion*

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INTRODUCTION

The hand plays a significant role in performing daily activities. The hand, the most active part of the upper limb, is also the least protected one.[1] The incidence of hand injuries is relatively high, and flexor tendons are commonly affected.[2] Hand is divided into five zones.[3] Zone V extends from the proximal border of the transverse carpal ligament to the musculotendinous junctions of the flexor tendon. Injury to this zone involves the median and ulnar nerves, radial and ulnar arteries, and wrist and finger flexors.[4] This type of injury has been labelled as 'spaghetti wrist', 'suicide wrist', and 'full house syndrome'.[3] Hand injury can be caused by an accidental cut, self-inflicted or by assault resulting in loss of hand function. Proper evaluation of the injured hand should be done.

Tendon injuries require urgently care, ideally within 24 hours of injury. Most frequent cause of failure after a flexor tendon injury is adhesion formation that prevents the

tendon from gliding.[5] Whenever needed, tendon injury repair should be done as soon as possible but delayed repair of the tendon is done because of associated injuries or some conditions. Preoperative counselling regarding the need for physiotherapy and regular follow-up should be emphasized. On the other hand, nerve injuries related to tendon lacerations in zone V may contribute to disability, and the outcome of nerve repair can affect the overall hand function. Although injuries in this region are not infrequent, only a few studies have reported functional effects.[3]

Delayed primary repair is defined as repair performed within two weeks after tendon laceration, and early secondary repairs are formed between 2 and 5 weeks. Repair of tendons can be delayed for various reasons like other injuries requiring immediate surgical intervention, severe wound contamination, delayed presentation.

The present study was undertaken to assess the functional outcome of flexor tendon injury following delayed primary and early secondary repair of zone V tendon injury of hand and to see the result of early mobilization of fingers in the recovery of hand function.

MATERIALS AND METHODS

The present research was conducted in Guwahati Medical College and Hospital in the plastic surgery department from January 2014 to August 2019. All the patients with zone 5 flexor tendon injury admitted in the plastic surgery department were included in the study. The inclusion criteria were patients clinically diagnosed with Zone 5 Flexor tendon injury, and the duration of the injury should be more than one day but less than five weeks. Patients attending the hospital before one day or after five weeks and those with a history of Hansen's disease were excluded.

It was a prospective clinical study, and prior approval for conducting the research was obtained from the institutional ethical committee of GMCH before commencing the study. Informed consent has been obtained from the participants. A detailed history of each patient was taken, along with systemic and local examinations. Necessary investigations for each procedure were done appropriately. Diagnosis of flexor tendon injury was made by history and clinical findings. The site and size of the wound were checked and recorded. Examination of the entire Flexor tendon was done and documented accordingly. The radiographs were taken to exclude fractures. Vascular status of the limb radial and ulnar and median nerves were also checked and noted. Duration and mode of injury, tendon and nerve involvement, preoperative assessment of the function (grasping and pinching) preoperative physiotherapy as necessary was done.

Intra-operative Period: All the patients were subjected to operation under general anaesthesia or regional anaesthesia. All aseptic and antiseptic measures were strictly followed. Following that, draping of the operative site was done, and a tourniquet was applied and time noted. After the operation, the slab was used, and the tourniquet was removed and checked for ischemic signs. The hand was splinted at 30-degree wrist flexion and 45 degrees MCP flexion, interphalangeal joint fully extended. The hand was elevated immediately after operation to prevent oedema till primary dressing. Intravenous cephalosporin groups were administered for three days, followed by five-day oral antibiotics. Analgesics were given for two day's followed by oral analgesia and anti-inflammatory accordingly. Patients were Discharged after primary dressing on five to7 days postoperative, and stitches were removed after 10 to 14 days postoperatively (**Fig. 2a- Fig. 2g**).

Rehabilitation protocol: Kleinert's dynamic elastic manual splint was applied after 24 hours continued till two weeks and physiotherapy started from day one onwards. Follow up was done twice weekly for the first two weeks. Splint modification by removing the distal interphalangeal joint guard by shortening of plaster cast up to middle phalanx and wrist flexion was extended from initial 30 degrees to 45 degrees. Weekly follow up were done for the next three weeks. Follow-up rehabilitation was done every three weeks for six months. The regular activity started after six weeks, and the patient was allowed to lift heavy objects for eight weeks in a gradual setup. Total active motion of individual fingers as per ASSH protocol was calculated as follows

Total active motion = Total active flexion - Total active extension deficit

Total active flexion = Flexion angle of DIP + PIP + MCP,
Total extension deficit = Extension lag angle of DIP + PIP + MCP
where DIP= distal interphalangeal; PIP= proximal interphalangeal and MCP= metacarpophalangeal
TAM percentage was calculated to grade the final functional outcome as follows
TAM % = TAM of the finger × 100/260

Hand activities were assessed according to the patient satisfaction as glass holding, ball compression, key pinch and pulp to pulp touch. Complications were recorded and managed accordingly.

RESULTS

Of 155 patients with zone V flexor tendon injuries, five were female and 150 male patients. The youngest patient was nine years, and the oldest was 62 years, with 29.7 years. Most common age group was 21-30 years. Most of the cases were of unskilled workers comprising 58.1%.

The right-sided involvements include 120 patients (77.4%),

while left-sided involvement includes 35 patients (22.6 %). The most frequent mechanism of injury was accidental injury by glass cut (100 patients), with 30 patients thrusting the hand intentionally (in anger) or by physical assault, and 25 cases were caused by road traffic accidents (**Table 1**).

Table 1: Mode of injury and their percentages

Mode of injury	Total no (%)
Glass cut	64.5%
Knife cut	19.4%
Machinery cut	16.1

The majority, 535 flexor digitorum superficialis (FDS), followed by a total of 465 flexor digitorum profundus (FDP) and 120 flexor carpi ulnaris (FCU), were found to be injured. The most common structure involved was FDS of the ring (145 patients), little finger (140patients), middle finger (135 patients), index finger (115 patients). FDP account for the second-most structure to be involved in the tendon injury. The FDP of the middle finger is the most common to be involved (130 patients), ring fingers with 125 patients, little finger 115 and index finger 95 patients (**Table2**).

Table 2: Structure involved

Structure involved	Total
FDS	535
FDP	465
FPL	60
FCU	120
FCR	75

The Interval between injury time the surgical intervention ranges from 5-to 28 days. Delayed primary repair was performed in 90 patients and early secondary repairs in 65 patients. (**Fig. 1**).

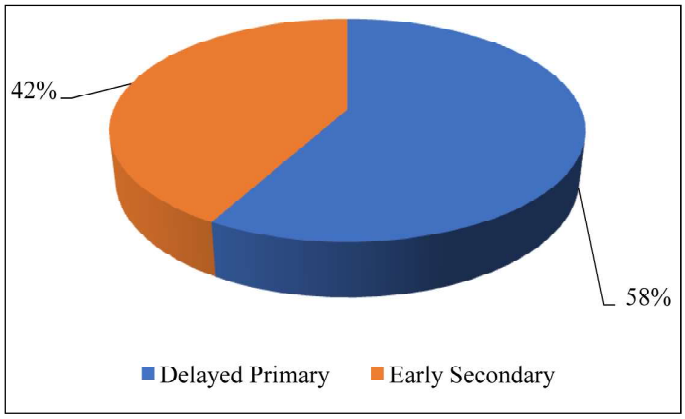

Fig. 1: Type of repair and number of cases

The average total active motions of fingers (TAM) of the hand were 181.25. The best TAM outcome was found in index finger 186.9, and worst was in ring finger 175.8. Ball compression activity had the best satisfactory outcome with 83.9% of cases. The worst outcome was pulp to touch with 58.3% satisfactory cases compared to 25 patients (41.7%) out of 60 cases involving FPL.

Four cases had wound infection, treated conservatively with regular dressing and oral antibiotics. One patient developed wound dehiscence for which a rotational advancement flap was done. Postoperative flap necrosis was encountered in two cases for which groin flap and rotation advancement flap was done. Adhesions happened in two cases for which local massage and ultrasonography therapy was given.

Fig. 2a Preoperative hand cascade lost

Fig 2b. Pre-op Sphygmomanometer assessment

Fig. 2c Intraoperative finding

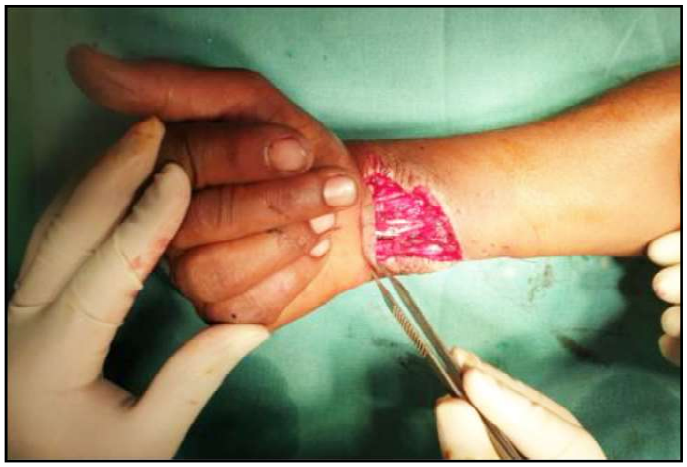

Fig. 2d Intraoperative repair

Fig. 2e Postoperative hand cascade restored

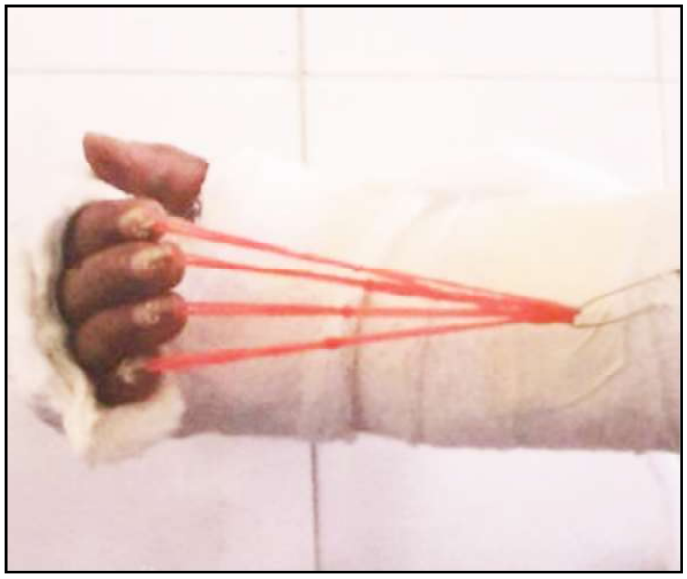

Fig. 2f Kleinert's manoeuver

Fig. 2g Post-op glass holding position

DISCUSSION

Hand is the most mobile part of the body, and tendons play an essential part in hand functioning. The superficial location of the tendons, nerves, and vessels in the wrist jeopardizes these structures with any penetrating injury.[6] Laceration with broken glass is the most frequent mechanism of injury in this region.[3,6]

Puckett and Meyer[6] reviewed 38 patients with extensive volar wrist lacerations. The patients had a minimum of three and an average of eight completely transacted longitudinal structures (tendon, nerve, or vessel) at the wrist. All except two had a significant nerve laceration. Protective mobilization of tendon repairs employing rubber band traction was used postoperatively. Tendon function was considered as excellent when the digital range of motion was 85%-100% of normal or finger flexion brought the fingertip within 1.0 cm of the distal palmar crease, good with 70%-84% of the normal range of motion or within 2.0 cm of the distal palmar crease, fair with 50%– 69% of the normal range of motion, or poor with fixed contracture or adhesions.

Stefanich et al.[7] reviewed 23 patients with zone V flexor tendon repairs mobilized using a Kleinert protocol. Total active motion (TAM) values of the injured digits and the corresponding unaffected numbers were calculated, as suggested by the American Society for Surgery of the Hand (ASSH). This involved a summation of values of active flexion of the joints of a single-digit minus the summation of extension deficits in those joints. Average TAM as a percentage of the uninjured contralateral digit was given

for the whole group of 23 patients for each of the five numbers, and this value ranged from 88% to 93%. Sixteen of the 23 patients regained full digital flexion of all digits. An average PIP extension deficit of 8 and a DIP extension deficit of 4. Tenolysis was needed in 4 (17%) patients. Two patients (9%) whose compliance with hand therapy was exceptionally poor had a minimal function.

Hudson and DeJager[8] studied 15 patients with simultaneous lacerations of both median and ulnar nerves with flexor tendons at the wrist. The authors attributed the poor outcome mainly to sepsis and poor patient compliance. Chin et al.[9] reviewed 60 patients with spaghetti wrist injuries. A good to an excellent range of motion of all involved digits was observed in all 19 patients available for a follow-up examination. No patient required tenolysis.

Most of the patients were male in our study, while only 5 were female patients. This is similar to the survey done by Muhammad S. R et al.[10] where most of the patients were male (M: F 2.4: 1). Similar findings were also reported b Gulzar S. A et al.[11]and Bircan C et al.[12]

In our study, most of the injuries were reported in the dominant extremity (77.4%). Jaffe and Eeckesser found similar results in their research.[13] In another study by Rahman MT et al., right side involvement were more than the left side.[14]

Most of the tendon injury causes in our study were accidental, which accounts for 75 cases (48.4%). The majority of the mode of injury was glass cut injury (64.5%), followed by knife cut (19.4%) and machinery injury (16.1%). These findings are similar to the study done by Reinisch et al.,[15] and Rahman MT et al.[14]

The most common age group to be involved was in the range of 21-30 years (54.8%). This result agrees with the study done by Reinisch et al.,[15] and Kunzle et al.[16] Most of the patients were unskilled workers (58.1%). The most common structure involved was FDS, followed by FDP. Similar findings were found in another study.[14]

In our study, those patients who had undergone tendon repaired by delayed primary repair had a better outcome than those repaired at early secondary. Different authors did several retrospective studies on zone V flexor tendon injury. Still, their studies were primarily focused on the functional outcome of the median nerve and ulnar nerve injuries. In our study, the functional results were evaluated by patient satisfaction in performing activities like holding a glass, compressing a soft ball, key pinch, pulp to pulp pinch by thumb and the injured finger, and ability to elevate sphygmomanometer above 20 mmHg. When measuring strength in the hand disabled subject, there are multiple advantages of a sphygmomanometer over the Jamar unit, including ready availability of a sphygmomanometer in most clinics, a soft compliant surface that may reduce minor discomfort to the injured hand during testing, and a scale with smaller increments than the Jamar Unit and, therefore, greater sensitivity to small changes in strength.[17]

In our study, 30 patients have developed complications, among whom 20 had wound infection at the stitch site, and 10 had flap necrosis. Gulzar SA et al.[11] reported 12% early postoperative infection, 8% adhesions resulting in limitation of movement at fingers, 4% rupture of tendon at the suture site due to the removal of the posterior splint 2 to 3 weeks after surgery. Another study has reported 3% tendon rupture and 3% contracture.[18] Elliot D et al. reported a 3-9% rupture rate.[19] The leading cause of complication may be delayed presentation and adhesion at the time of repair. There might be associated factors like wound contamination, the nature of wounds like laceration, avulsion with soft tissues and skin loss at the time of injury, which are significant factors responsible for postoperative complications.

Limitation: To evaluate the different outcomes of the tendon repairs in various time intervals, a more extensive and comparative study with a larger sample size may be undertaken.

CONCLUSION

Tendon repair has a better Outcome with Delayed Primary Repair than Early Secondary Repair, according to the Total Active Motion Percentage Grading System of The American Society for Surgery of Hand. Postoperative early mobilization results show satisfactory outcomes of the hand activities. Wound infection was the most common complication, followed by adhesions and flap necrosis. Thus, zone-V flexor tendon repair depends on the magnitude of the injury, early repair, early mobilization, regular physiotherapy, and overall patient compliance.

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Contribution of Authors: We declared that this work was done by the authors named in this article, and the authors will bear all liabilities about claims relating to the content of this article.

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