Primary Tendon Repair and Early Controlled Mobilization in ZONE I-IV Injuries of Hand Our Experience and Clinical Outcome

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Abstract:
Background: Tendon injuries are the most common injuries and present in a wide spectrum depending on the mechanism of injury. Hand injuries are most debilitating considering the impact it has on the daily activities. The prompt primary treatment gives the best outcome. Other essential elements required for a near normal function include technique of surgery, post-operative care and physiotherapy protocol. **Objective:** To assess the presentation, epidemiology and clinical outcome of early controlled mobilization in Flexor Zone I-IV hand injuries. **Methods:** This prospective study was conducted for a period of three years from December 2019 to November 2022 in a tertiary hand care centre. Flexor tendon injuries in adults in Zone I-IV were included in the study. A two layer closure with modified Kessler's core suture and epitenon suturing was done using 4-0 and 5-0 round polypropylene sutures respectively. A custom designed PVC splint was designed pre-operatively in all patients for post-operative splint age. Early controlled mobilization in the form of passive flexion and limited active extension was started from postoperative day one. Palm to pulp (PTP) distance method was used to assess the functional outcome at 6 weeks, 3 months and 6 months. **Results:** The study included 221 patients. Zone II injuries (52%) were the most common followed by Zone III (30%).102 (46%) patients had the combined flexor digitorumsuperficialis (FDS) and flexor digitorumprofundus (FDP) injuries. Flexor pollicislongus injuries were found in 19 (9%) of cases. Other associated nerve, intrinsic muscle and soft tissue injuries were found in 16% of cases. Metal roofing (steel sheet) injuries (28%) followed by machine cut injuries (24%) were the most common mode of injuries. PTP distance was less than 3cm in 73%, 82% and 82% of patients at 6 weeks, 3 months and 6 months respectively. **Conclusion:** A meticulous primary surgical repair with a well programmed physiotherapy protocol consisting of early active controlled mobilization gives good functional outcomein Zone I-IV flexor tendon injuries of hand.
Key words: Hand injuries, Zone I-IV flexor injuries, Tendon Injuries

Introduction

Injuries of the hand need special care to restore the near normal state and thereby improve the functional outcome. The flexor zone injuries are one of the most challenging injuries in hand. If not treated with exceptional care and concern may result in disastrous outcome.[1]Primary and early surgical repair followed by guided physiotherapy protocol usually produces a good and acceptable result.[2] The flexor tendon injuries of Zone I-IV usually occur in young males while working with machines or sharp objects like glass or metal sheets.[3] An inadequate primary treatment and physiotherapy results in most unsatisfactory outcome.[4]

Flexor tendon injuries are divided into five zones. Zone V is a zone proximal to wrist and usually gives excellent post-operative results. This zone has been excluded from this study. There are variety of techniques prescribed for the tenorrhaphy of flexor tendons.[5-8] Similarly a wide range of physiotherapy protocols are given in literature with a set of advantages and disadvantages, although the modified Duran's protocol is widely accepted.[9-10]

Post-operative assessment of tendon excursion and functional outcome has been studied by various authors and many protocols like the Total Active Extension Deficit, Total Active Flexion, Boyes' method, Louisville system, Pulp to Palm Distance (PPD), Total Active Motion (TAM) scale have been devised.[11-14]

Our study focussed on the various presentations, epidemiology and clinical outcome following early controlled mobilization in Flexor Zone I-IV hand injuries.

Materials and Methods

This study has been conducted in a tertiary care hospital which caters to a vast population and is the only referral centre to the hand and microvascular surgery cases in the area. The study is a prospective study, conducted over a period of 3 years from Dec 2019 to Nov 2022. Adult patients (Age 14-60years) with Zone I-IV flexor tendon injuries of hand wereincluded in the study. All the chronic cases, pediatric patients, Zone VI injuries, doubtful soft tissue coverage, bony fractures, cases requiring two stage procedure or simultaneous soft tissue reconstruction were excluded from the study.

A two layer closure with modified Kessler's core suture and epitenon suturing was done using 4-0 and 5-0 round polypropylene sutures respectively. A custom designed dorsal blocking PVC splint was designed pre-operatively in all patients with standard angles at wrist and metacarpophalangeal joints for post-operative splintage.

Early controlled mobilization in the form of passive flexion and limited active extension was started from postoperative day one and continued for three weeks, followed by active assisted flexion and limited active extensionfor another three weeks. After six weeks the splint was removed and patients asked to do active movements at all joints and assist with other hand in case of any stiffness or lack of mobility at any joint. Place and hold exercises were also prescribed in all patients at 6 weeks. Grip strengthening exercises were started at 8 weeks. Patients were advised to start their normal day to day activities while avoid lifting heavy weights and manual labour for next 3 months.

Functional outcome was assessed by using White's Palm to Pulp (PTP) distance method by measuring the distance between pulp of the digits to the distal palmar crease with fingers in full flexion at 6 weeks, 3 months and 6 months. The results were considered excellent, good, fair and poor when the PTP was 2cm or less, 2-3cm, 3-4 cm and greater than 4cm respectively.

Results:

A total number of 221 patients who fitted the inclusion criteria were enrolled in the study. 82% (181 patients) were males mostly in their prime youth. Zone II was the most common zone involved (52%)

followed by Zone III (30%).(Table 1)A combined flexor digitorumsuperficialis (FDS) and flexor digitorumprofundus (FDP) injury was the most common presentation (46%)followed isolated FDP injury (42%).(Table 2) Flexor pollicislongus injury was found in 9% of cases and 16% of patients had other associated injuries like nerve injury and other soft tissue injuries. Injury by steel sheets (roofing sheets) is the most common mode of injury comprising of about 28% of injuries followed by trauma due to machine (24%) and glass cut injuries (21%).(Table 3)

Grading of functional outcome recorded by PTP (Pulp to Palm) distance revealed excellent/good results in 73%, 82% and 82% of patients at the end of 6 weeks, 3 months and 6 months respectively.(Table 4) The assessment was done on patients who reported regularly on OPD follow-up visits. There were many patients who did not adhere to follow-up protocol and could not be evaluated. For this reason the total number of patients assessed at6 weeks, 3 months and 6 months was 204, 189 and 137 respectively.

Wound infection, wound dehiscence, stiffness and tendon disruption were the chief complications.(Table 5)

Table 1: Distribution of Patients according to injuries in various Flexor Zones of Hand (I-IV)

Zone	No. of patients
I	23 (10%)
II	115 (52%)
III	67 (30%)
IV	16 (7%)

Table 2: Distribution of patients in terms of injuries sustained

FDP injury	93 (42%)
FDS injury	7 (3%)
Combined FDS and FDP injury	102 (46%)
FPL injury alone or with others	19 (9%)
Other Associated injuries (Nerve, intrinsic muscles of hand etc)	34 (16%)

Table 3: Mode of injury

Cause	No. of Patients
Metal roofing (steel) sheets	62 (28%)
Machine injury	54 (24%)
Glass cut	46 (21%)
Knife cut	28 (13%)
Road traffic accident	23 (1%)
Misc	8 (4%)

Table 4: Outcome of Primary repair and early controlled mobilization

OUTCOME	Week 6 (204 patients)	3 Months (189 patients)	6 Months (137 patients)
Excellent	58 (28%)	73 (39%)	61 (45%)
Good	92 (45%)	82 (43%)	51 (37%)
Fair	42 (21%)	26 (14%)	12 (9%)
Poor	12 (6%)	8 (4%)	9 (7%)

Table 5: Complications associated with Zone I-IV Flexor tendon repair

Wound infection	18 (8%) out 221
Dehiscence/soft tissue necrosis	11 (5%) out of 221
Stiffnessat 6 months	15 (11%) out of 137
Tendon Disruption at 6 months	6 (4%) out of 137

Discussion:

Understanding the fine anatomy and intricately designed biomechanics of hand is of paramount importance in achieving successful surgical outcome in hand injuries.[15]The operative technique, timing of repair and post-operative rehabilitation protocol are essential for attaining quintessential functional results.

We chose adult age group who could cooperate well with the physiotherapy and follow-up protocol. Patients with bony injuries, soft tissue injuries and other associated injuries which would hamper early mobilization protocol were excluded from the study.

The management of Zone I-IV flexor tendon injuries is demanding for the treating surgeon as well as the patient. The successful outcome depends not only on the surgical technique but more so on the patience, co-operation and compliance of the patient in adhering to the post-operative rehabilitation protocol. Zone II injuries have the worst results and the zone has been truly labelled as "no man's land".[16]

Lot of techniques have been described in literature for flexor tendon repair.[17]We prefer a standard two layered closure with a modified Kessler 2-strand core suture using 4-0 round polypropylene followed by epitenon repair using 5-0 round polypropylene. Similar technique has been used by many authors with fairly good results.[18]

In our series steel sheet injuries (28%) followed by machine injuries (24%) and glass cut injuries (21%) comprised the bulk. The roofs of the houses are mostly made of steel sheets. Hand injuries usually result from slipping and trying to catch the sharp edge of these sheets, while clearing snow off rooftops. People also use these steel sheets for fencing and injure their hands while trying to cross over these dangerous sharp edged fences.

Flexion tendon repair results are directly linked to the metacarpo-phalangeal and inter-phalangeal range of motion.[19]Our post-operative rehabilitation and follow-up strategy made sure that these joints attain and maintain mobility as soon as possible. We followed the above mentioned physiotherapy protocol in the out-patient department, though the recording for this study include data at 6 weeks, 3 months and 6 months.

Complications in our study included wound infection, dehiscence which could be managed with dressings and proper culture based antibiotic regimen. Stiffness (due to non-compliance) and tendon

rupture resulted in poor outcome.[20,21,22]Grading of functional outcome recorded by White's PTP (Pulp to Palm) distance revealed excellent/good results in 73%, 82% and 82% of patients at the end of 6 weeks, 3 months and 6 months respectively. Early controlled mobilization and the physiotherapy protocol ensured good post-operative outcome. Early mobilization of joints helps prevent post-inflammatory fibrosis and adhesion formation and decreases joint stiffness considerably. For the patients to be complaint, a good assistance should be rendered early on to make them understand the protocol completely. The patients should receive good analgesia and anti-inflammatory medication in post-operative period to reduce swelling and pain, thereby increasing compliance to physiotherapy. As shown in table 4, significant number of patients were lost to follow-up. Patients who reside in far flung areas usually avoid frequent visits due to time and money constraints. Also some of the patients who experience significant improvement in digital mobility during the follow-up period stop nvisiting the hospital.

Conclusion:

Primary repair of flexor tendons in Zone I-IV hand injuries followed by a well devised physiotherapy protocol consisting of early active controlled mobilization produces good to excellent results and decreases joint stiffness considerably. Awareness among the masses about the commonest modes of this type of injury and its crippling results if not treated properly can help decrease the number of such events and improve the outcome significantly.

Authors Declaration: Hillal Ahmad Bhat is the First Co-Author along with Mir Yasir. JunaidKhurshid is 2nd Author. The authors declare that there is no funding source or conflict of interest. Consent for study has been properly sought.

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