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Evaluation of extensor tendon repair of hand

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Abstract
Extensor tendon injury is one common hand injury occurring in young individuals. Extensor tendons are superficially located with minimal amount of subcutaneous tissue that predisposes the extensor mechanism to more complex tendon injuries. Surgical repair of extensor tendon requires an exact knowledge of anatomy, careful adherence to some basic surgical principles, sound clinical judgment, strict atraumatic surgical technique and a well-planned postoperative programme. We conducted this study to find out common causes of extensor tendon injuries, evaluation of hand function after repair of extensor tendon injuries and evaluation of effect of time elapsed between onset of injury to tendon repair on the final outcome. The functional outcome after tendon repair was assessed by calculating Total Active range of Motion (TAM). After the evaluation of result we concluded that the higher percentage of excellent and good cases is might be attributable to strong and meticulous repair in which more aggressive physiotherapy was tolerated by the patients and the tendons should be repaired preferably primarily.

Keywords: Extensor tendon, Total active range of movement, Extensor zones, Spinltage, Rehablitaion

Introduction
Human hand is highly adaptable organ of prehension, sensation, expression and communication. It has very complex and integrated structures such as skin, muscles, tendons, nerves, vessels, bones and joints. All these components contribute to the performance of highly coordinated actions of hand. Dysfunction of this unit can cause severe disability of hand.

Injuries of hand are quite common in working individuals and Extensor tendon injury is one common hand injury occurring in young individuals in the prime of their lives [1]. Extensor tendons are superficially located with minimal amount of subcutaneous tissue that predisposes the extensor mechanism to more complex tendon injuries [2].

Primary treatment with restoration of normal anatomy in a single operation is required to achieve the best possible outcome [3]. Inadequate primary treatment is likely to give poor long-term results [4]. Surgical repair of extensor tendon requires an exact knowledge of anatomy, careful adherence to some basic surgical principles, sound clinical judgment, strict atraumatic surgical technique and a well-planned postoperative programme.

The extensor tendon injuries have been divided into eight zones as recommended by Kleinert and Verdan [5]. Even-numbered zones are over bones; odd-numbered zones are over joints. Doyle considered the forearm area of extensor muscle bellies as a ninth zone [3].

Management of tendon injuries is dependent on the location and type of injury and repair should take place very soon after the injury especially within the first 2 weeks [6].

Primary repair has been widely used to reunite severed tendons since the 1960's and in recent years early active mobilisation has been accepted as the ideal rehabilitation method. The whole new concept of tendon healing has undergone a revolutionary change but still the perfect suture and ideal mobilization technique eludes this.

AIMS and objectives
We conducted this study to find out common causes of extensor tendon injuries and evaluation of hand function after repair of extensor tendon injuries.

We also aimed at comparing the results achieved after extensor tendon repair in different zones and evaluation of effect of time elapsed between onset of injury to tendon repair on the final outcome.

Material and methods

We conducted a prospective study on total of 30 cases with an extensor tendon injury admitted in the department of Orthopaedics of Government Medical College, Amritsar from June 2011 to September 2013. Patients having concomitant flexor tendon injury were excluded from the study. In this study only functional recovery related to the tendons were assessed.

Clinical history, general physical examination and local examination was performed and patients were investigated for operative and anaesthetic purposes after informed written consent.

The supportive and prophylactic therapy in the form of analgesics, antibiotics, anti-tetanus injection, I.V. fluids, matched blood transfusion, wherever required, were given.

Injured hand was X-rayed to know any associated bony injury.

Before doing any operative work the following criteria were fulfilled:

1. Fairly good range of the passive movements at the joint acted upon by the injured tendon.
2. Absence of wound erythema and swelling suggestion inflammation or potential infection.
3. Adequate skin coverage
4. Relative freedom from scar of the tissue in which tendon was expected to glide.
5. Satisfactory alignment of the bones and properly healed fractures.
6. Intact or restorable sensation especially of the fingers.

In case criteria were not being fulfilled due to one reason or the other, treatment was given for that, e.g.

1. In case of stiff joints pre-operative physiotherapy was given to improve upon the function
2. In case of dense cicatrix, it was excised during the operation.
3. In cases of cut nerves, repair was done at the same time.
4. In case of associated fractures, fixation was done at the same time.

Patients were subjected to general anaesthesia/regional anaesthesia. Atraumatic technique was adhered to throughout the operation. In all the patients, Modified Kessler repair technique was used for the repair of extensor tendons. Non-absorbable monofilament (Prolene) suture was used.

In neglected cases, to cover the gap, free tendon grafts were used. After the repair, wound was closed with fine, interrupted non-absorbable suture. Sterile dressing was then applied along with a volar splint extending from proximal phalanx to proximal forearm. Wrist held in 30^0 extension and MP joints flexed at least 45^0 and IP joint free to mobilize.

Postoperative care

Appropriate postoperative antibiotics were given. The first postoperative dressing was done on the fifth day. Stitches were removed on 12th and volar splint was changed with wrist held in 20^0 extension, metacarpophalangeal (MP) joint flexion at 0-30° and interphalangeal (IP) joints free to mobilise. Controlled active mobilization was begun on the first postoperative day. The patient was instructed to carry out two exercises actively (1) Combined IP and MP joints extension, and joint extension with IP joint flexion. Volar splint was removed on 3rd week. First follow up was done after 3 weeks, then after 4 weeks. K wires which were used for fixation of fractures removed at 4th week. Further follow-ups were done at 2 weekly intervals for 3 months.

Evaluation of results

The functional outcome after tendon repair was assessed by calculating Total Active range of Motion (TAM) as suggested by American Society for the Surgery of Hand (ASSH). This was done by adding active flexion at metacarpophalangeal, proximal interphalangeal and distal interphalangeal joints, after subtracting the sum of extension deficit at these joints. Recovery was calculated as percent–regained motion compared to normal range of motion (270).

$$\frac{(\text{PIP Flexion} + \text{DIP Flexion}) - (\text{Extension Deficit of DIP \& PIP})}{175^0} \times 100 = \% \text{ of Normal motion}$$

Results were evaluated according to Modified Strickland's classification.

Modified Strickland, as shown, was the grading system used in the analysis.

Grade	Percentage range
Excellent	75 - 100%
Good	50 – 74%
Fair	25 – 49%
Poor	0 – 24%

Observations and results

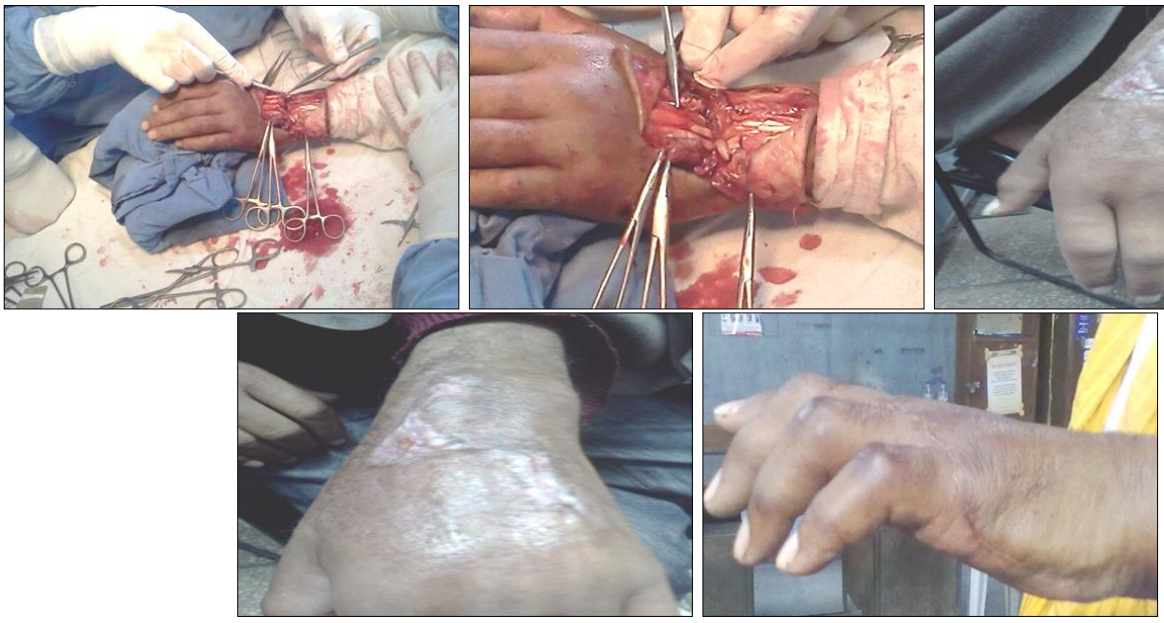
Out of a total of 30 patients 28 were males and 2 were females. Maximum number of them, 53.33% (n=16) presented in the 3rd decade of life. 66.67% of the cases sustained right hand injury (n=20). Most common etiological factor of tendon injury was individual scuffle 73.33% (n=20) followed by everyday life injuries seen in 20% of the cases (n=6). Most of the injuries were seen in zone VI and VII involving 53.33% cases (n=16) followed by zone VIII and IX 20% (n=6).

Table 1 shows time elapsed from the injury to primary treatment where in 60% patients reported for treatment within six hours. Figure 1 shows that only 20% (n=6) cases approached the medical college for primary treatment while bulk of the patients were treated at other health centers. Time elapsed between the injury and operation varied from one day to three months and only 13.33% patients (n=4) were operated within first 24 hours as shown in table 3 / Figure 2.

It was found that bone involvement was seen in 26.67% patients (n=8) and joint involvement was there in 13.33% patients (n=4).

Case 1: tendon repair of zone ix injury showing excellent result

Case 2: tendon repair of zone viii, showing excellent result



Case 3: tendon repair of zone vii showing stiffness of the joint leads to poor result

Case 4: tendon repair of zone vi showing good result

The results were categorized and assessed depending upon the following factors. 1) Time elapsed between injury and operation. 2) Site of the tendon lesion. 3) Effect of patient co-operation in follow up periods. 4) Effect of physiotherapy.

Table 4 shows time elapsed from the injury to operation and the end result. It was found that patients who were operated within first 24 hours, 75% of them showed excellent result and 25% had good result. Those operated from one to three months of injury had a sharp decline with only 50% cases showing good and fair results.

Postoperative physiotherapy and adherence to the treatment plan is necessary for complete recovery. As shown in table 5 highly co-operative patients 85% patients had excellent results while uncooperative patients had only fair (75%) and poor (25%) results.

It was found that patients with zone VIII and IX involvement had excellent recovery with 100% results as shown in table 6. The recovery rate started falling in cases where hand and fingers were involved with 55.5% and 57% excellent results respectively.

In all, nine patients had a failure. On careful scrutinization of these cases, probable causes of failure to achieve the ideal results are shown in table 7

Table 1: Time elapsed from the injury to primary treatment

Time	No. of patients	% age
Less than 6 hours	18	60%
More than 6 hours	12	40%

Table 2: primary management of the patients

Primary treatment provided by	No. of Patients	% age
Emergency Department of a Medical College	6	20.00 %
Civil Hospitals	8	26.67 %
Primary Health Centre	8	26.67 %
Rural dispensary	2	6.67 %
Railway Hospital	1	3.33 %
Surgical specialist	1	3.33 %
MBBS doctors	3	10.00 %
Unqualified	1	3.33 %

Table 3: time elapsed from the injury to operation

Time elapsed between the injury and operation	No. of Cases
Within 24 hours	4
1-3 days	7
4-7 days	10
7-14 days	6
15-30 days	1
1-3 months	2

Table 4: the time elapsed from the injury to operation and the end result

Time elapsed	Results (No. of cases)			
	Excellent	Good	Fair	Poor
Within 24 hours	3	1		-
One to three days	4	1	1	1
Four to seven days	7	-	2	1
Seven days to one month	5	1	-	1
One to three months	-	1	1	-

Table 5: effect of patient co-operation in follow up period on results

	Result (no. of cases)			
	Excellent	**Good**	**Fair**	**Poor**
Highly co-operative	12	2	-	-
Co-operative	7	2	1	2
Uncooperative	-	-	3	1
Total	19	4	4	3

Table 6: site of tendon lesions and end results

Tendon		**Result (No. of cases)**			
	Zone	**Excellent**	**Good**	**Fair**	**Poor**
	IX	3	-	-	-
	VIII	2	-	-	-
	VII	7	-	1	2
	VI	3	2	1	1
Extensor	V		-	1	-
	IV	1	-		1
	III	-	1	-	-
	II	1	1	-	-
	I	2	-	-	-

Table 7: probable causes of failure to achieve the ideal results

Probable cause	**No. of patients**
Pre-operative condition (Tendon laceration, cut capsule, multiple tendons involved, skin condition)	6
Un-cooperative patient	4
Wound infections	3
Adhesions	5
Time elapsed from the injury to operation	2
Tendon rupture	1

Discussion

Extensor tendon injuries can cause serious functional impairment if not timely intervened. The management of these injuries demand the same skill and knowledge as required for flexor tendon injuries [7, 8]. On the dorsum of the hand and fingers there is a relative lack of soft tissue, therefore adhesions of the tendon to skin are common, the bone and joints being very close to the dorsal surface are injured concurrently with extensor tendons. These tendons have no vincula; their blood supply is segmental, arising from the surrounding soft tissue and paratenon. Extensive dissection devitalizes these tendons and promotes scarring.

Tendon injuries were more often found in persons at their best working age (18 to 50 years). In the present prospective study, 87% of the patients were between this age group. Maximum number of patients were in 3rd decade of life (16 patients; 53.33%). Slater RR *et al* [9] found similar incidence where most of the patients were between 20 to 40 years. In the present prospective study, dominant right hand was injured in 20 patients (66.67%) and so was reported by Crosby CA *et al* [10] and Pandey VK *et al* [11].

Numerous causes of tendon injuries have been mentioned in the literature by Fowler SB *et al* [12] and Saini *et al* [13] and these vary widely in different series probably because of difference in demographic and social situations. Analysis shows that in 3rd and 4th decade, the commonest cause was individual scuffle. In our study also 73.33% patients sustained injuries to the tendons in individual scuffles followed by everyday life injuries seen in 20% patients.

As described by Doyle JR *et al* [3] and Blue AL *et al* [4] initial treatment is of the utmost importance because it often determines the final outcome; inadequate primary treatment is likely to give poor long term results. Surgical repair of extensor tendon requires an exact knowledge of anatomy, careful adherence to some basic surgical principles, sound clinical judgment, strict atraumatic surgical technique and a well-planned post-operative programme.

In our study 60% patients reported within first six hours while 40% reported for treatment after six hours. Also only 20% patients received primary treatment in medical college (by Orthopaedics team) while 77% patients received primary treatment from doctors other than orthopaedic specialist and 3% had taken treatment from quacks. A study conducted by Mason *et al* [14] described the following causes of negligence: a) Poor facilities at the hospital. b) Lack of experience on the part of attending surgeon. c) Poor general condition of the patient. d) Condition of the wound. e) Associated injuries.

Extensor tendons have been divided into different zones by various authors. In the present series we used the classification of Kleinert and Verdan. The most common site of injuries were zone of VI, VII, total consist of 16 patients (53.33%) respectively, while VIII and IX consist total of 6 patients (20%) in this study. The Study conducted by Saini N *et al* [13] described that forty two per cent (n=11) injuries were in Zone VI and 35% (n=9) in Zone VII. This observation is understandable since these two zones are vulnerable to trauma.

Most of these injuries worldwide are repaired under regional block the extensor tendon repair under supraclavicular brachial block with tourniquet and had no anaesthesia related complications. We avoided giving axillary block as it may leave an area in lateral part of arm proximally which may have to be anesthetized separately for tourniquet application.

Slater RR *et al* [9] conducted a study and found that lesser the time elapsed from the injury to primary repair; the better the results are. In the present study four patients were operated within first 24 hours of the injury and 75% of them had excellent end results, comparable to the study conducted by Slater RR *et al*.

We chose Modified - Kessler technique for the repair and

achieved 63.33% excellent results, 13.33% good results. Newport ML *et al* [15] examined the long-term results of extensor tendon repair in 101 digits treated with traditional static splinting, achieving 45% good or excellent results. Both simple injuries and those with the addition of joint capsule injury only achieved 64% good to excellent results. Crosby CA *et al* [16] used dynamic splinting giving 92% good to excellent results. Hence it is concluded that controlled early active mobilization gives better results than static splinting and it's comparable to dynamic splinting protocol.

Hung LK *et al* [17] concluded that injuries distal to knuckles (zones II, III, IV) showed worst results with an average total active motion of only 188 degrees (range, 95 to 270 degrees). Our study also reveals that all the patients with zone VIII and IX achieved excellent results while lesions involving digits had variable results.

Conclusion

1. Repairs with modified Kessler technique were technically easy to perform with a relatively short learning curve.
2. The higher percentage of excellent and good cases in might be attributable to strong and meticulous repair in which more aggressive physiotherapy was tolerated by the patients
3. The tendons should be repaired preferably primarily.
4. Post-operative early controlled mobilization provides better rehabilitation in extensor tendon injuries.
5. The motivated and educated patients may be put on active motion protocols, with each subsequent visit the load and the type of exercise may be stepped up increasing load bearing.
6. Regular follow up of all repaired extensor tendon is advisable in third week, and then next week, then every 2 weeks for at least three months.

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