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Comparison of the Repair Techniques for Extensor Tendon Injuries in the Hand

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Abstract:- Fifty three patients (97 fingers) with extensor tendon injures in the metacarpal and wrist zones were included in this prospective study, with average age of 28 years. Metacarpal zone was involved in 70% of cases and extensor tendon was injured in 82 fingers and 15 thumbs, 62% of the patients were treated surgically within 7 days of injury. In general, mattress suturing technique was used in 65 digits (67%) Kessler in 21 (22%) and Cruciate11 (11%) with splinting range between 4 to 6 weeks. After average of 5 months follow up, the results scored according to millers classifications; was excellent in thirty one fingers (32%), good in 49(50.5%), fair in 14 (14.4) and poor in 3(3.1%).In thumb, in 60% the Cruciate technique was used and Kessler in 33% and the results were excellent to good in 80% . In the other fingers, Mattress technique of suturing was used in 78%, and the Cruciate in 2.5%. 25 fingers (30.5%) were classified as excellent,43(52.5%) good, and unsatisfactory in 14(17%).In conclusion, we found that Mattress suture technique is simpler and quicker, it can be used in the repair of multiple small flat extensor tendons in multi-injured fingers. And augmented 2-strand Kessler and 4-strand cruciate techniques are stronger extensor tendon repair techniques that allows early and safely mobilization, in one or two injured fingers with tubular shape or thicker tendons.

I. INTRODUCTION

Extensor tendon injuries in the hand relatively common, because of its superficial anatomical location with lack of synovial sheath covering on the dorsum of the hand and fingers (less protected), so they are highly susceptible to injuries, from lacerations ,bites, burns , blunt trauma and open injuries or crushing's which may associated with sever tissue damage [1]. Extensor tendon injuries encountered more frequently than the flexor tendons, contrary to the general belief, injuries of extensor tendons do represent a significant challenge in the treatment and rehabilitation [2]. The extensor tendons are thin, flat, weaker than flexor tendons with less gliding amplitude, and are difficult to suture well. They may often associated with open joint injuries which makes difficulties in late reconstruction techniques [2-3]. Single or partial tendon injuries over the dorsum of the hand may be difficult to diagnose by merely testing extensor function, because many of the extending forces are transmitted from adjacent and interconnected extensor mechanism which is known as Juncturae Tendini [2].

So to produce the best possible document we should have clear knowledge about the anatomical status of extensor tendons at metacarpal and wrist regions, sufficient history and examination with testing the functional status. So is to evaluate the best surgical repair techniques according to the number of injured tendons and slips, location, and the effect of other influencing factors, with their effect on the final outcome of treatment.

II. MATERIALS & METHODS

From December 2008 to August 2010, 53 hands (97 fingers) with extensor tendon injuries at metacarpal and wrist zones where surgically treated in orthopedics department in Basrah general hospital. Hands with associated soft tissue loss, fractures, complex traumas, old tendon injuries and with insufficient follow up where excluded from the study.

Before surgery, history was obtained for the mechanism, severity and duration of injury, and also for the functional disabilities, in addition to the hand dominance, occupation and previous hand injuries or diseases.

All hands were assessed and examined for the wound site, extent, clearance or signs of infection and the multiplicity of different tissue types injured (nerves, bones ,vessels) ,and also for the position of injured fingers after cut and the ability of active finger extension and flexion.

Treatment consisted of primary, delayed primary and secondary repair according to time of presentation to our department since injury.

Operations were performed on 125 injured tendons under general or regional anesthesia with tourniquet control, usually exposed through lazy S incisions depending on the type and direction of the wound, careful dissection and manipulation of the tendon ends or slips was performed and sometimes with sharp dissection (beveling) of the scared ends for refreshening.

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All tendons were repaired using 4/0 prolene (polydioxanone) and in most cases this was supplemented with a 5/0 prolene epitendinous suture around the circumference of the tendon junction. Three different repair techniques were performed, as horizontal Mattress, Kessler(two-strand core suture), and Cruciate (four- strand core suture) depending on the number and size of tendon or its slips injured, and in addition to the duration of injury.

After completion of the repairs, tourniquet released followed by homeostasis and irrigation with normal saline and then wound closure.

Immobilization in volar splint with wrist, MP and PIP joints in extension while DIP joints free, and early postoperative active movements of the fingers was encouraged, after 2 weeks the stitches was removed and volar splint was changed leaving the PIP and DIP joints free, the duration of splinting ranged from 4-6 weeks depending on the strength of the suture technique and patients compliance, then fully mobilized with physiotherapy. During the postoperative follow up, all patients had assessment for active movements of the MP and IP joints, extensor lags, pulp to palm distance and associated local complications.

The results were assessed by the Millers classification and Kleinert /Verdan classification systems. [3-13-14].

Table 1 Miller's Classification of the Results after Extensor Tendon Repair

Result	Total Extensor Lag	Total Flexor Loss
Excellent	0degrees	0 degrees
Good	<10 degrees	< 20 degrees
Fair	11-45 degrees	21-45degrees
Poor	> 45 degrees	> 45 degrees

Table 2. Kleinert & Verdan Classification System (ASSH[1])

Result	Total Active Motion (TAM)
Excellent	Normal
Good	>75% of the normal side
Fair	>50% ,<75% of the normal side
Poor	<50% of the normal side

III. RESULTS

Fifty three patients (97 fingers, 125 injured tendons) were included in the study, the male/ female ratio was 8-1 (Table 3), with age ranged between 7 to 61 years (average 28 years) .

Table 3 Gender Distribution

Sex	Number of Patients	%	Ratio
Male	48	91	8
Female	5	9	1
Total	53	100%	8-1

Right hand was injured in 36 cases (68%), while left in 17(32%). Metacarpal zone was the most common, involved in 70% of the cases. (Table 4).

Table 4. Zone Distribution

Zone	Number of Fingers	Number of Patients	%
Metacarpal	56	37	70
Wrist	41	16	30
Total	97	53	100%

Approximately 41 injuries (77 %) resulted from sharp objects (glasses and knives), mostly at work. (Table 5).

Table 5 Causes of Tendon Injury

Causative Objects	Number	%
Glass	24	45.2
Knife	17	32
Tank plate	4	8
Cleaver	2	3.7
Saw	2	3.7
Cutter	2	3.7
Machine thread	2	3.7
Total	53	100

Most of the cases where between 21 to 40 years of age (70%) and below 20 years in 20.6% (Table 6).

Table 6 Distribution According to the Age

Range of Age in Years	Number of Patients	%
<10	1	1.8
11—20	10	18.8
21—30	26	49
31—40	11	21
>41	5	9.4
Total	53	100%

[1] ASSH ,American society of surgery of the hand

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Extensor tendons were injured in 82 fingers and 15 thumbs, and the middle finger was slightly the most affected. (Table 7).

Table 7.Location of the Extensor Tendon Injuries

	Number	%
Thumb	15	15
Index	21	22
Middle	24	25
Ring	20	21
Little	17	17
Total	97	100%

Table (8) shows the specific tendons injured in each digit, the extensor digirorum communis was the highest, in the index both tendons(EDC & EIP) were injured in17 fingers and only EDC in 4, in the little both tendons(EDC & Edq) were injured in 11 fingers and only EDC in 6 .

Table 8 Tendons Injured

The Tendon	The Finger	Number	%
Extensor pollicis longus	thumb	15	12
Extensor digirorum communis	Index	21	16.8
Extensor indicis proprius	Index	17	13.6
Extensor digirorum communis	Middle	24	19
Extensor digirorum communis	Ring	20	16
Extensor digirorum communis	Little	17	13.6
Extensor digiti quinti	Little	11	9
Total		125	100%

Most of the patients were treated within 7 days of injury (62%) as shown in table (9).

Table 9 Duration of the Injury

Duration in Days	Number of Patients	%
1-7	33	62
8-14	12	23
>15	8	15
Total	53	100%

According to the table above the treatment consisted of early repair in 33 hands, delayed primary in 12, and late in 8.

The techniques used to repair differs according to the finger, site, extent and number of extensor tendons injured, in addition to the duration; in general, mattress technique used in 65 digits(67%)or 86 tendons(68.8%). (Table 10).

Table 10 Repair Techniques

Repair Techniques.	Number of Fingers & %	Number of Tendons	%
Mattress	65 (67%)	86	68.8
Kessler	21(22%)	27	21.6
Cruciate	11 (11%)	12	9.6
Total	97 (100%)	125	100

The average period of static splintage postoperatively for all the cases was 5 weeks (range between 4 to 6 weeks).

The follow up period for the patients after removal of splint was from 2 to 18 months (average 5 months)

Early complications, during the follow up period; 4 hands sustained infection and were treated by antibiotics , 1 hematoma, and one with tendon rupture due to early removal of the splint.

The results scored according to millers classifications (Table 11); thirty one fingers(32%) were classified as excellent, 49(50.5%) good, 14 (14.4) as fair and 3(3.1%) as poor.

Table 11 Results of the Treatment

Result	Number of Fingers	%
Excellent	31	32
Good	49	50.5
Fair	14	14.4
Poor	3	3.1
Total	97	100%

So in the study the overall excellent to good outcomes were obtained in 82.5 of the fingers, while 17.5% showed limited finger flexion, extension lag, adhesions and tendon rupture. Thumb (Table 12)

In thumb, 15 Tendons (EPL) were injured, 8 in the metacarpal zone and 7 in the wrist, 9 fingers injured alone without associated other fingers, 13 digits (87%) repaired within first week, in 60% the Cruciate technique was used and Kessler in 33%. The results were excellent to good in 80%.

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Table 12.Thumb Results According to the Zone, Duration and the Repair Technique

		Numb	Excellent	Good	Fair	Poor
zone	MCP	8 (53%)	2	4	2	-
	Wrist	7(47%	4	2	1	-
Duration (days)	1-7	13(87%)	6	5	2	-
	8-14	2(13%)	-	1	1	-
Repair technique	Cruciat	9(60%)	4	3	2	-
	Kessler	5(33%)	2	2	1	-
	Matters	1(7%)	-	1	-	-
total		15 thumbs	6(40%)	6(40%)	3(20%)	-

In 3 thumbs at the last follow up the result was fair; 2 had limitation of digit flexion and one extension lag. Fingers (Table 13)

Extensor tendons were injured in; 21 index fingers, 24 middle, 20 rings and 17 little, 59% were in the metacarpal zone and 41% in the wrist, approximately 80% were repaired within 2 weeks. Mattress technique of suturing was used in 78% of the fingers, and the Cruciate in 2.5% which was in the index only, while most of the tendon slips in the ring fingers repaired by Mattress technique which was 18 fingers (90%) out of 20.

According to Millers scoring of the results; 25 fingers (30.5%) were classified as excellent, 43(52.5%) good, and unsatisfactory in 14(17%).

Only 19 digits injured alone without other fingers involvement, excellent to good outcomes were obtained after repair in 18(95%) and poor in one.

Table 13. Fingers Results According to the Zone, Duration and Repair Technique

		Numb	Excellent	Good	Fair	Poor
Zone	MCP	48(59%)	15	26	4	3
	Wrist	34(41%)	10	17	7	-
Duration (days)	1-7	50(61%)	21	24	5	-
	8-14	16(19.5%)	4	10	2	-
	>14	16(19.5%)	-	9	4	3
Repair technique	matters	64(78%)	18	34	10	2
	Kessler	16(19.5%)	5	9	1	1
	Cruciat	2(2.5%)	2	-	-	-
total		82 fingers	25(30.5%)	43(52.5%	11(13.4%)	3(3.6%)

In 11 digits the outcome was fair during the follow up; four had limited finger flexion, 2 finger joints stiffness, 4 with extensor lag and 1 hands with Sudecks atrophy.

Three digits represented with poor outcome; two complicated with adhesions, and one had tendon rupture due to early removal of the splint and were subjected for further surgery.

IV. DISCUSSION

Extensor tendon injuries of the hand represent a significant challenges in the treatment and rehabilitation, because it is thin, flat, difficult to suture well, require cautious evaluation, handling and treatment. 27 Without proper treatment can result in weakness of active extension and decreased in the flexion of the IP joints.26 Seventy percent of the patients were active, between 21 to 40 years of age, 77% of the injuries in the study were sustained by sharp objects, causing 28(29%) single finger injury while multiple in the most 69(71%), as reported that most of sharp injuries does not discriminate between one tendon and another.16 We found that extensor tendon injuries at the wrist were less (30%) in comparison to the metacarpal zone (70%) , as mentioned in part one the extensor tendons less protected in the metacarpal zone [4].

Many suturing techniques have been used for the repair of extensor tendon injuries in order to gain strong and safety suturing and to avoid the development of adhesions, flexion limitations and tendon ruptures [5, 6].

We use 3 different methods of suturing depending on the injured finger and number of tendons and duration of the injury, timing of the repair classified into primary (within 12 hours of injury) , delayed primary (within14days) and secondary(between 2 and 4 weeks) [7]. In the study 85% of the injured fingers were repaired within 2 weeks, and

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excellent to good results were obtained in 73%, as described the repair should take place soon after injury , preferably within the first 2 weeks. [8]

In 15 thumbs, 80% were rated as excellent to good outcomes after repair; 87% were treated within one week, 9 EPL tendons (60%) were repaired by Cruciate type with 4 strand core suture and epitendinous suture, 5 (33%) were repaired by Kessler technique with epitendinous suture, and one (7%) by Mattress type because the EPL tendon was composed of two small slips. Several techniques augment the repair strength and gap resistance, and core suture techniques are designed to withstand the forces of early active motion, facilitate gliding, and limit postoperative tendon adhesions, authors favor the technique of increasing the number of core sutures or strands crossing the repair site, adding grasping or epitendinous stitches, and they revealed that epitendinous stitches can add as much as 50% to the overall strength of a tendon sutured [9,7,10,11,12].

Some articles reported that Cruciate type of repair is slightly more complex, because of its multiple passes, furthermore it relies on having an abundance of tendon length and width in which to perform the multiple weaves and requires a substantial time to perform. [6,10,12]. Others recommended , the use of a standard Kessler suture for tubular shaped tendons and the horizontal Mattress suture for flat tendons [5].

The results after repair of the EPL tendons, showed that the four strand cruciate technique and Kessler are the preferred methods with satisfactory outcomes, for repairing 1 to 2 tubular tendon injures rather than multiple digits or tendon injuries.

Eighty two fingers were repaired in the study, 61% within 1week, 19 digits (23%) injured singly while 63(77%) in combinations, the excellent to good results was obtained in 68 digits (83%). 78% of the fingers were repaired by Mattress technique and only 2.5% by Cruciate method in the index.

Over the dorsum of digits the extensor tendon itself is thin and is covered with loose connective tissue .32 the Mattress technique with additional sutures, is simple, stiffer and faster to perform than others and can be easily manipulated during surgery which takes less time to perform, but gapping or rupture of the repair would likely result in early active motion protocols .34 As considered that the horizontal mattress suturing in the metacarpal zone allow earlier mobilization ,24 so we feel this technique did well in multiple tendon injuries with thin, and flat slips, particularly in the ring finger (we always found composed of about 3 to 4 small slips), and the four strand Cruciate or two strand Kessler techniques were the best for 1 to 2 tendons injury as in the index.

Several postoperative immobilizations and management protocols were applied to the fingers, depending on the level of injury, strength of the suturing, and traditional management of extensor tendon repairs has been by immobilizing repaired tendons for 4-6 weeks .[5] the average duration of splinting in our patients was 5 weeks with early finger exercises, mainly depending on the repair strength and we could achieved satisfactory functional outcomes in 82.5% of the injured digits by this regimen .

Strickland stated that active digital motion generates greater gliding of the healing tendon, fewer adhesions, and more rapidly tendon strength[27,30].and static splintage has been shown to produce reasonable good results in extensor tendon injuries in all zones [13,14]. Tendon adhesions can occur after prolonged splinting causing loss of flexion and extension of the injured fingers ,19 and the goal of rehabilitation after tendon repair is to achieve optimal function, while preventing tendon rupture by respecting the mechanical limitations of the chosen technique .[10,6].

In the study during the follow up period, 17(17.5%) of the repaired fingers ended with fair to poor outcomes, 2 thumbs ended with flexion limitations and extension lag in one.

In the other 14 digits; four had limited finger flexion, 2 finger joints stiffness, 4 with extensor lag and 1 hands with Sudecks atrophy, and those with poor outcomes two complicated with adhesions, and one had tendon rupture. We think finger flexion limitation may be due to tendon shortening or stiffness, and gapping at repair site may lead to extension lag.

Early complications following tendon repair include hematoma, infection, tendon rupture and poor tendon gliding. Hematoma itself can lead to an increase in adhesions because of increased inflammation during hemolysis. [6]

The failure modes of tendon repair were classified as tendon breakage, suture breakage or suture pullout, it is generally accepted that successful extensor tendon repair should promote tendon nutrition and gliding and minimize extensor lag and tendon shortening, and when extensor tendon repair shortens the tendon , MP joint flexion decrease [5, 16, 17]

Adhesion formation and decreased repair strength have been linked to the handling repair site and local soft tissue injury and duration of splinting, in addition early digital motion promotes tendon gliding ,limits adhesions and improves the tensile properties of the repair site .[5,6,7,10,15]

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The dilemma becomes restoring normal strength and range of motion while minimizing adhesions and protecting tendon healing from rupture and repair site gapping .29Hauge concluded that extensor tendon repairs always do well but did not measure loss of flexion after repairs .[5]

V. CONCLUSION

Acute tendon injury is one of the most frequently encountered problems in hand, even a successful tendon repair may lead to disappointing results, so; to achieve optimal outcomes it requires proper suturing techniques that allow early mobilization, in attempt to prevent undesirable complications.

From the above results we found that Mattress suture technique is simpler and quicker, therefore it can be used in the repair of multiple flat extensor tendon injuries in multiple injured fingers.

Augmented two strand Kessler and four strand cruciate techniques are an adequate stronger extensor tendon repair techniques that allows early and safely mobilization, in one or two injured fingers with more oval or thicker tendons.

Accordingly, the key of the treatment of extensor tendon injuries are, the knowledge of hand anatomy, an accurate diagnosis, technically detailed surgical repair and most importantly the postoperative rehabilitation to offset loss of function.36

RECOMMENDATIONS

- Education and training; poor surgical techniques and lack of knowledge regarding tendon anatomy, biomechanics and tendon healing mechanisms, jeopardize the treatment outcome.
- Tendon repair techniques; because of the development of more advance techniques for tendon repair, we expect more to be learned about optimal repair techniques for the injured tendons in the hand.
- Sophisticated rehabilitation programs; the treatment of tendon injuries has improved due to therapies and rehabilitation protocols developed, and inadequate rehabilitation systems prevents functional restoration of the injured hand.

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