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Intratendinious Versus Extracorporeal Knot Four Strand Core Suture Repair of Flexor Tendon Injuries of the Hand Zone II

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Abstract

Background: Over the past few years, there has been a shift in how flexor tendons are repaired. Because of adhesions or ruptures that occurred when early active motion was attempted, flexor tendon repairs in the digit have a long history of producing disappointing outcomes.

Objectives: To make an evaluation to the outcomes of flexor tendon repair using ordinary 4 strands suture with intratendinous knot technique and comparing it with four strands suture with extracorporeal knot. And comparing it with our innovation technique; The four-strand suture with extracorporeal knot.

Subjects and Methods: This interventional prospective trial was performed on persons admitted to our emergency hospital and Burn and Plastic Surgery Center, Mansoura University with flexor tendon injuries zone II from February 2020 to February 2023. Patients were classified into two groups; group A treated with the 4-strand suture with extra corporeal knot, and group B treated with the 4-strand suture with intra tendinous knot.

Results: Statistical analysis revealed a statistically significant distinction among the groups according to outcome, total active flexion (TAF) and total active range of motion (TARM) for group A, and operation time for group B. No statistically significant variations were observed amongst the groups as regard socio-demographic characteristics, injury location & dominant hand distribution among the study populations, anesthesia WALAIAT or General, follow up period, patient or parent's satisfaction, age and outcome of treatment.

Conclusion: We noticed that the four strands suture with extracorporeal knot technique for flexor tendons repair zone II was easy to accomplish, had a lower volume and no bulk at the site of repair, with no suture knot inside tendon at site of repair, besides a more regular suture, that offer less interfering with tendon gliding, less adhesion formation, adequate strong repair for an early active post-operative mobilization protocol, good results, good total active range of motion and good patients satisfaction.

Key Words: *Intratendinious – Extracorporeal knot – Strand core suture.*

Disclosure: No conflict of interest.

Ethical Committee: Acceptance of our institutional review board (IRB) and patient consent.

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Introduction

Many alternative suture designs have been documented for tendon repair, which is a typical treatment for tendon damage. A number of alternative repair procedures are used in the clinical setting, demonstrating that there is currently no unifying methodology for tendon repair despite numerous in vivo clinical investigations as well as in vitro tensile experiments comparing various suture methods **[1]**.

There are many factors have a great importance for an ideal tendon repair, meticulous handling, suture technique, maintaining glide between the tendon and sheath, reducing tendon damage and minimizing adhesion formation, care to avoid neurovascular injuries also must be observed. Another factors provide greater strength repair and permit healing is a peripheral circumferential suture and prevention of gapping formation **[2,3]**.

The advancement of flexor tendon operation is focused on achieving a strong suture tendon construct that enables early active movement. This is the eventual goal of this line of research. Early mobilization has been observed for enhancing the results of flexor tendon repairs by decreasing the construction of peritendinous adhesion as well as triggering intrinsic tendon healing. As a consequence of this, gapping is also a technical flaw that, in theory, can be remedied by a repair that is more long-lasting & uses less plastic. It is well established that early mobilization improves the overall result of flexor tendon repairs **[4]**.

One of the most popular methods for repair of flexor tendons of hand zone II is the four-strand technique with Intratendinious knot because it is very strong suture that allow early active post-operative mobilization without increasing the rupture rate. But the location of the knot intratendinous increase bulk of tendon at repair site that interfere with gliding of tendon that stimulate adhesions formation which limits active range of motion. Other complications include tenolysis, triggering, gab formation, even tendon rupture, joint contracture, pulley failure with tendon bowstringing. Less common problems include quadriga, swan-neck deformity, and lumbrical plus deformity [5].

So, the goal of the research was to determine the effectiveness, strength, outcome, post-operative complications and patients' satisfaction of flexor tendon regeneration employing ordinary four strands suture with intratendinous knot technique and comparing it with our new technique four strands suture with extracorporeal knot.

Patients and Methods

The trial was interventional randomized controlled clinical study was applied on cases admitted to our emergency hospital and Burn and Plastic surgery center, Mansoura University with flexor tendon injuries zone II from February 2020 to February 2023 (about 30 cases) after acceptance of our institutional review board (IRB) and patient consent.

Patients were categorized into two groups, the odd numbers were in group A, and the even numbers were in group B.

Inclusion criteria: Cases were involved in this trial if they had hand trauma with flexor tendon injury (cut of FDP &/or FDS) zone II, immediate injury or delayed injury within one month.

Exclusion criteria: Patients were excluded if they had associated phalangeal fractures, crushing hand injury or soft tissue loss.

The determination of the sample size was determined by the mean total active movement that was obtained from prior research comparing microsurgical repair of flexor tendon using non-knot Kessler suture in addition to traditional Kessler suture [6].

Calculating the variance among two means using the t test with two tails, effect size = 1.55, α error = 0.05, & power = 95.0 percent using G power. The overall number of people in each group was estimated to be 12, but after adding 20 percent to account for people who might not show up for the survey, the total number of people was calculated to be 15.

Workup plan (Methodology):

Pre-operative: Primary survey and history taking about the nature of injury, dominant hand, and a physical examination of the hand, which must include an inspection of the natural flexion cascade of the digits. If one digit is hyperextended in comparison to the others, there is a good chance that a flexor tendon transaction will occur. In addition to that, a neurovascular exam is required. CBC, PT, & INR are the laboratory tests. Imaging: Plain hand-X-ray: To exclude bone fracture.

Intra operative: After local or general anesthesia, the tourniquet was applied and then sterilization was done, Tendon exposure was achieved via rectangular skin flaps.

Suture technique: Group A: patients were treated with four strand technique with extracorporeal knot (proline 4-0 rounded tip). Extracorporeal knot means the knot will be fixed outside the finger on a button after stitching the proximal end of tendon at site of injury as ordinary four strand technique, and passing through distal end of tendon through needle till outside finger, then fixation and ligation of passing loops on this button on tip of finger (diagram 1). Group B: Patients were treated with four strand technique with intratendinous knot (proline 4-0 rounded tip).

A peripheral epitenon suture (proline 6-0) in addition to the core suture was taken and post-operative dorsal blocking splint hold the wrist in mild flexion, the MCP joints in 80 degrees of flexion and the PIP and DIP joints in full extensions was done in both groups.

Post-operative: Early active mobilization physiotherapy program was done aiming to improve tendon healing, reduce fibrosis, adhesions and improve overall functional outcome.

Statistical analysis: Version 22 of the statistical tool for the social sciences known as SPSS was utilized for the analysis of the information. Quantitative data was evaluated for normality using the Shapiro-Wilk test followed by using the standard deviation, mean, & range for normally distributed data besides the median & range for data that was not normally distributed. Qualitative data was provided as numbers in addition %. The proper statistical test was applied in accordance with the type of data, with the following tests being offered as possible alternatives: Chi-Square, also known as the "Categorical Variable Test," the Student *t*-Test, as well as the Mann Whitney U Test.

Results

In the extracorporeal group, the mean age was 24.17±14.6 (range: 3-46) years, and in the Intratendinious group it was 29.2±11.93 (range: 5-49) years with no statistically alteration amongst the

studied groups (p=0.318), as regards socio-demographic features (p above 0.05). (Table 1).

Both the dominant hand & the location of the injury didn't vary significantly amongst the two groups (p over 0.05). (Table 2).

In the extracorporeal group, the mean operative time was 64.33±9.04 (range: 50-75) minutes, and in the Intratendinious group it was 51.67±8.38 (range: 35-60) minutes. The alteration among both groups was statistically highly significant (p under 0.001) and no significant disparities among groups regarding type of anesthesia (p=0.651). The mean follows up period was 13.27±1.58 (range: 12-16) weeks, In the extracorporeal group, and in the intratendinous group it was 13.53±1.46 (range: 12-16) weeks, statistically, there is no distinction amongst the groups (p=0.623). (Table 3).

In the extracorporeal group, the mean TAF was 258.67±9.9 (range: 240-270) degrees, and in the Intratendinious group it was 232±30.52 (range: 170-270) degrees. The variance amongst both groups was significant statistically (p=0.006). In the extracorporeal group, the mean EL was 23.34±12.91 (range: 0-60) degrees, and in the Intratendinious group it was 16±9.1 (range: 0-30) degrees with not a statistically significant distinction observed among the 2 groups (p=0.111). In the extracorporeal group, the mean TARM was 235.33±13.02 (range: 210-270) degrees, and in the Intratendinous group it was 216±30.66 (range: 150-270) degrees. The difference between both groups was substantial according to the statistics (p=0.039). (Table 4).

No statistically significant change amongst each of the groups as regard correlation between patient or parent's satisfaction and age, outcome of treatment among group A. (Table 5).

When comparing patient & parent satisfaction with age in addition treatment outcomes, group B did not significantly vary from the other groups. (Table 6).

Table (1): Socio-demographic characteristics of the researched groups.

	Group A N=15	Group B N=15	Test of significance
Age/years:			
Mean±SD	24.17±14.60	29.20±11.93	z=0.975
Median (IQR)	23 (10-35)	28 (21-36)	p=0.329
Sex n (%):			
Male	10 (66.7)	10 (66.7)	p=1.0
Female	5 (33.3)	5 (33.3)	

IQR: Interquartile range. z: Mann Whitney U test. p: Probability.

Table (2): Distribution of the studied groups according to injury site and dominant hand.

	Group A N=15 (%)	Group B N=15 (%)	Test of significance
Dominant hand:			
Right	10 (66.7)	11 (73.3)	χ2=0.159
Left	5 (33.3)	4 (26.7)	p=1.0
Injured hand:			
Right	7 (46.7)	9 (60)	χ2=0.536
Left	8 (53.3)	6 (40)	p=0.464
Injured finger:			
Ring	3 (20)	4 (26.7)	MC=1.24
Middle	3 (20)	5 (33.3)	p=0.743
Little	6 (40)	4 (26.7)	
Index	3 (20)	2 (13.3)	

χ2: Chi-Square test. MC: Monte Carlo test.

Table (3): Distribution of the examined groups regarding operation characteristics.

	Group A N=15	Group B N=15	Test of significance
Operation time Mean ± SD	64.33±9.04	51.67±8.38	t=3.98 p<0.001*
Anesthesia	n (%)	n (%)	
WALAIAT	11 (73.3)	13 (86.7)	FET=0.833
General	4 (26.7)	2 (13.3)	p=0.651
Follow-up period	13.27±1.58	13.53±1.46	t=0.481 p=0.635

t: Student t-test. *Statistically significant. FET: Fischer exact test.

Table (4): Comparison of outcome between studied groups.

	Group A N=15	Group B N=15	Test of significance
TARM:			
Mean ± SD	235.33±13.02	216±30.66	t=2.25 p=0.03*
EL:			
Mean ± SD	23.33±12.91	16.0±9.10	z=1.76
Median (IQR)	20 (20-30)	20 (10-30)	p=0.078
TAF:			
Mean ± SD	258.67±9.90	232.0±30.52	t=3.22 p=0.003*

t: Student t-test. *Statistically significant. IQR: Interquartile range.

Table (5): Correlation between patient or parent's satisfaction and age, outcome of treatment among group A.

		Patient or parents satisfaction
Age / years	*r*	–.174
	p-value	.534
TARM	*r*	.150
	p-value	.593
EL	*r*	–.325
	p-value	.237
TAF	*r*	–.238
	p-value	.394
Operation time (minutes)	*r*	.125
	p-value	.658

r: Spearman correlation coefficient.

Table (6): Correlation between patient or parent's satisfaction and age, outcome of treatment among group B.

		Patient or parents satisfaction
Age / years	*r*	–.423
	p-value	.116
TARM	*r*	.283
	p-value	.306
EL	*r*	.253
	p-value	.363
TAF	*r*	.243
	p-value	.384
Operation time (minutes)	*r*	–.227
	p-value	.416

r: Spearman correlation coefficient.

Diagram (1): [Four strand technique with extracorporeal knot]

Fig. (1): Rectangular skin flaps.

Fig. (2): Tendon exposure after dissection of skin flaps.

Fig. (3): FDS tendon repair.

Fig. (4): Passing two stitch loops through the proximal end of tendon.

Fig. (5): Introduce two needles through distal end of tendon.

Fig. (6): Passing two proline loops through tendon till outside finger.

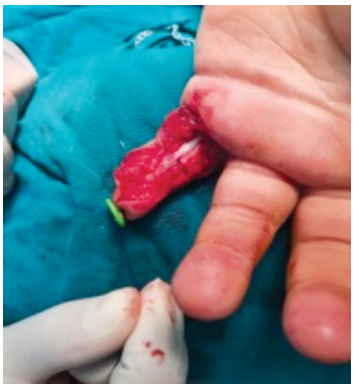


Fig. (7): Loops fixation on tip of finger.

Fig. (8): Peripheral epitenon suture.

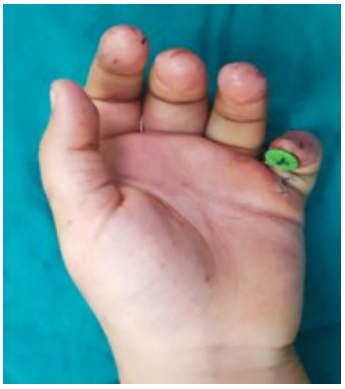
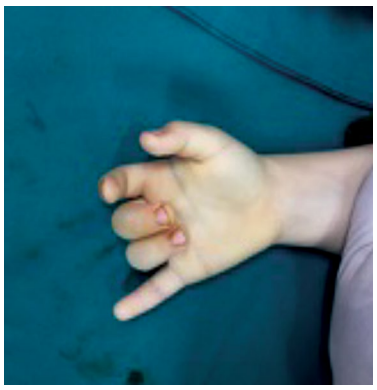


Fig. (9): Closure of skin flaps and return of normal cascade.

Fig. (10): Dorsal splint.

Case Presentation

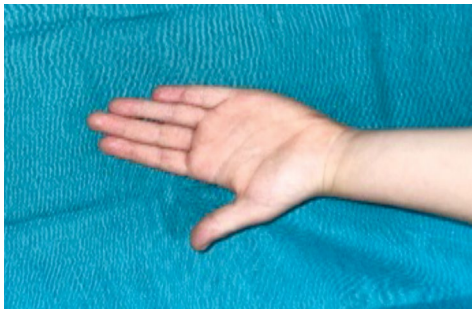
Case (1): A 3.5-year-old male person with cut FDP of the right little finger zone II. Pre-operative presentation (Fig. A). Intra operative, FDP repaired with extra corporeal knot (Fig. B). Active flexion and extension 12 months postoperatively (Fig. C1, 2).



(A): Pre-operative.

(B): Intra-operative.

(C1): Active Flexion.



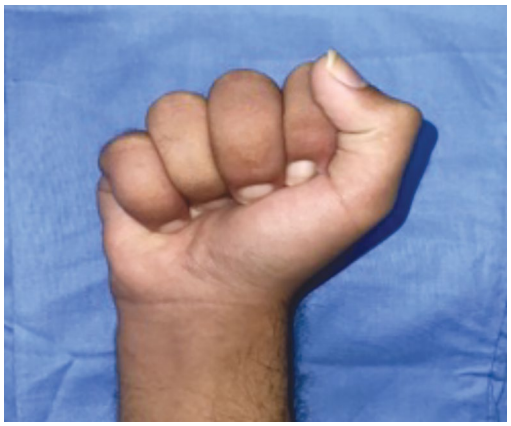
(C2): Active Extension.

Case (2): A 23-year-old male individual with cut FDP of the middle, right index also little fingers zone II. Pre-operative presentation (Fig. A). Intra operative, FDP repair with Intratendinious knot (Fig. B). Active flexion and extension 12 months postoperatively (Fig. C1, 2).

(A): Pre-operative.

(B): Intra-operative.

(C1): Active Extension.



(C2): Active Flexion.

Discussion

To repair a flexor tendon so that it can withstand immediate stress without rupturing, numerous research has looked into different suture materials and methods to see what works best **[7]**.

In particular, Zone II flexor tendon lacerations have seen tremendous advances in surgical treatments during the past two decades. When compared to practices popular even 20 years ago, today's clinical procedures are revolutionary **[8]**.

Regarding to establish publishing results that rising the total number of threads that cross the repair site will improve the power of the repair and allow early active post-operative mobilization without increasing the rupture rate, so using 4-strand technique in this study and the results was good function and no repairs ruptured.

In addition to increasing the number of threads of the repair, The location of the knots (intratendinous vs extratendinous) and the addition of a peripheral epitenon repair, also determining the strength of tendon repair **[9]**. Tang 2022 confirmed that, the placing of knots outside the tendon surface does not compromise tendon glide & actually improves repair strength **[8]**. In accordance with Chen and colleagues, burying the knots within the tendon stumps in a 4-strand repair will make the repair site slightly more prone to gap, even when tensioned. Therefore, when performing a multi-strand repair, the knot should be placed outside the tendon surface **[10]**.

In our study we used the knot away from the tendon surface and presented on button on the tip of finger to allow smooth tendon gliding and decrease adhesion formation.

There is a debate about which is better outcomes on flexor tendon repair; simultaneous repair of both FDS & FDP tendons or only repair FDP. Moriya & Michael confirm that Repair of both FDP as well as FDS tendons significantly better outcomes and enlarged work of flexion **[11]**.

However, Zhang Jun Pan & coworkers avoided repairing the FDS in their series, which may have aided in beneficial results by reducing the possibility of adhesions amongst the FDP along with FDS tendons in addition to facilitating easier tendon gliding after the repair procedure **[12]**.

In our study we repaired both FDP and FDS tendons and our results were strong flexor grip and no tenolysis rate due to absence of knot inside FDP tendon and no tendon bulk which increase the tendon gliding resistance and stimulating adhesion formation with FDS and we agree with a lot of studies that recommended fix the FDP in addition to the FDS in region II.

The result of this study disagrees with Pan and Marume who determined that zone 2C injuries caused the most functional issues for zones 1 to 3 as well as were a substantial negative predictor of flexor tendon repair efficacy. Results from zone 2C, as published by Moriya in addition to coworkers, were clearly below those from zones 2B & 2D. **[13,14]**. Our explanation regarding to in our technique there is no suture knot inside tendon which increase tendon bulk at site of repair and interfere with gliding into pulley.

Regarding the rehabilitation protocols, The Kleinert procedure for controlled passive motion is still widely employed. Using the Kleinert technique, 'excellent' & 'good' findings in the 70-100 percent range have been documented in the protocol **[15]**. Primary flexor tendon repair rehabilitation now commonly includes early active digital flexion **[8]**. While most series report excellent as well as average case rates around seventy & ninety percent, we discovered that using an early supervised active rehabilitation regimen led to rates of eighty-nine in both groups **[16]**, but consistent with the most recent reports **[17]**. This may be because of the intensive one-on-one care that each patient receives, the regularity with which they receive it (every other day in the case of postoperative oedema), as well as the attention they receive from their healthcare providers.

As regard exclusion criteria in the current study, patients having finger fracture, soft tissue loss, and vascular injury necessitating revascularization have been excluded. This is similar to exclusion criteria in Singh et al. These factors can alter method of repair or rehabilitation and affect final results, so they were excluded to have well matched study group and to detect factors affecting results of the repair itself **[18]**.

Conclusion:

We noticed that the four strands suture with extracorporeal knot technique for flexor tendons repair zone II was easy to accomplish, had a lower volume and no bulk at the site of repair, with no suture knot inside tendon at site of repair, besides a more regular suture, that offer less interfering with tendon gliding, less adhesion formation, adequate strong repair for an early active post-operative mobilization protocol, good results, good total active range of motion and good patients satisfaction.

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