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ORIGINAL ARTICLE

Comparative Study Between Four Strands Cruciate Technique Versus Two Strands Kessler Technique in Repair of Flexor Tendon Injuries

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Abstract

Background: **Due to a variety of harmful agents, flexor tendon injuries of the hand are a problem that frequently occurs. It can sometimes be linked to phalangeal fractures and/or nerve or blood vessel injuries, which can have a significant negative impact on functional limitations and lifestyle choices.**

Aim of the work: **To contrast the two strands Kessler technique and the four-strand cruciate technique for the repair of flexor tendon injuries.**

Patients and methods: **our study included twenty patients who were divided into two groups for this prospective interventional controlled single blinded study, which was carried out at the plastic surgery trauma emergency unit and outpatient clinic at AL-Zahraa University hospital from December 2021 to January 2023.**

Results: **Group A: excellent to good in 80 % of patients (excellent 50 % and good 30 %), 1 fair 10 % (due to an infection started 5 days post operatively that delayed the start of the rehabilitation protocol) and 1 poor 10 % (due to adhesions post operatively). Group B: excellent to good in 70 % of patients (excellent 30 % and good 70 %), 1 fair 10 % (due to skin contracture) and 2 recorded as poor (due to adhesions). Despite the overall results, but there was a significance difference in favor of Group A regarding the quality of motion i.e. motion arc, coordination and speed. Group A: 70 % of patients had excellent quality of motion compared to only 20 % in Group (B), While 10 % recorded as poor in Group (A) compared to 60 % in Group (B).**

Conclusion: **In terms of motion range, grip strength, the zone of injury, and the likelihood of complications, this study indicates that flexor tendon injuries can be successfully managed by either two or four strands repair techniques. However, using a four-strand locked cruciate instead of a two-strand Kessler, then starting early postoperative controlled active rehabilitation will lead to a better functional outcome, particularly in terms of motion quality, such as motion arc, coordination, and speed.**

Keywords: Flexor tendon injuries, Four strands cruciate, Strands kessler

1. Introduction

During normal daily activities a variety of harmful agents can cause severe hand injuries, especially flexor tendons, impacting the lives of both sexes and distinctive age groups. They may be associated with phalangeal fractures and/or nerve or vessel injuries, which may cause serious functional disabilities that have adverse effects on one's ability to work and normal lifestyle.[1]

Regaining normal grip strength, finger and wrist movement and hand function after a flexor tendon repair is one of the most difficult goals to achieve. Tendon repair complications such as tendon rupture, gapping, adhesions, and joint stiffness are all influenced by the mechanism of injury, the repair method, the severity of injury, age and the rehabilitation programme.[2]

There have been significant improvements in our understanding of tendon anatomy, mechanics and

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the biology of healing, which will help preventing complications related to tendon repair, such as tendon rupture, gapping, adhesions and joint stiffness.[3]

Despite this, there is still disagreement regarding the best surgical repair method that can prevent these side effects and provide the patient with the best functional outcome to enable resuming a normal life.[4]

Historically, there has always been a debate surrounding the surgical management of flexor tendon injuries. The first experimental research on tendon healing was not done until John Hunter in the middle of the 1700s. Early research by Bunnell identified the issues with constrictive adhesions near the flexor tendon repair sites. Primary tendon repair was not performed for the first time until the 1960s, but the initial success rates were not always satisfactory.[5]

At the American Society of Hand Surgery, a paper titled Primary repair of flexor tendons was presented in 1967. This published excellent results and sparked the adoption of this technique into mainstream medicine. As a result, many surgeons started to report positive outcomes from flexor tendon primary repairs. Additionally, a lot of experimental studies were started with a focus on postoperative recovery, suture methods, suture materials and flexor tendon healing. Research was sparked by the growing interest in primary flexor tendon repair, which led to new inquiries about how to speed up the healing process.[6]

Numerous studies have demonstrated that using postoperative protocols that include either passive or active motion of the repaired tendon can enhance patient outcomes.[7]

Adequate strength of suture repair is a must for starting early motion protocols to withstand elevated tensile power, increased flexion work due to oedema and operating process and the cyclic impact of the tendon loading,

Several studies have shown that the more suture strands crossing the site of repair the stronger the repair; however, those complex techniques require additional handling at the tendon site during repair, rendering them less practical.[8]

2. Patients and methodology

This prospective interventional controlled single blinded study was conducted at AL-Zahraa University hospital's plastic surgery trauma emergency unit and outpatient clinic from December 2021 to January 2023; our study included 20 patients split into two groups: **Group A (10 patients):** Tendon repair using four strands cruciate locking repair with epitendinous circumferential suture. **Group B (10 patients):** Tendon repair using modified Kessler technique, knot-in with epitendinous circumferential suture.

After examining all flexor injuries tentatively, repair was done and patients continued to follow up at the outpatient clinic for three to six months.

Patients of our study: Group A (10 patients): (8 in zone II, 2 in zone V). Group B (10 patients): (7 in zone II, 1 in Zone III, 2 in Zone V).

Criteria of inclusion: Male and Female patients of any age group who has acute or old trauma.

Criteria of exclusion: patients with high level of nerve Injury and any congenital hand anomalies.

We obtained approval from the research ethics committee and a written consent from all cases in this study. Patients were treated the same way as any other trauma patient.

General anesthesia was used in nine patients, while wide awake local anesthesia no tourniquet (WALANT) technique was used for the remaining eleven patients. Tourniquet applied whenever needed to reduce the blood loss from the skin incision. Exposing the injured tendon with a Zigzag incision.

After making the oblique zigzag incision, debridement and irrigation are carried out, after which an accurate reevaluation of the injured structures, for retrieval of retracted tendon ends, we have adopted the standard techniques, delicately we refreshed the tendon ends whenever needed.

The tendon sutures were done by these methods: **Group A:** using four strands cruciate core suture technique by using non-absorbable Prolene (3/0) (Fig. 1), **Group B:** using two strands by using non-absorbable Prolene (3/0) (Fig. 2).

The surgical repair strategy utilized in **Group A** fulfills nearly all of the criteria for a strong repair, including number of strands crossing the repair ends, tension repair, diameter of suture knot over the tendon, suture caliber and circumferential sutures over the repair site.

The injured tendons in the different hand zones (II, III, and V) were repaired. After surgery, early active mobilization of the repaired digit began immediately (3–5 days later), and the hand was placed in a protective splint with the wrist slightly flexed (20–30°), the MCP joints slightly extended, and the interphalangeal joints slightly flexed. Follow up period with an average of three to six months.

This is agreed with **Braga-Silva, J.** study who claimed that after flexor tendon repair, postoperative programs with early active flexion can yield positive results.[9]

*Fig. 1. Non-absorbable four-strand cruciate locking repair Prolene 3/0 (**Group A**).*

The active range of motion, in addition to grip strength and motion quality were three factors used in the current study as used by **Tang (2007)** to assess clinically the quality of repair and to record the result of finger flexor repairs.[10]

Postoperative Follow up:

Patients were seen once a week for the first three weeks following surgery, at the end of the fifth week and after the third month, then with varying frequencies in accordance with individual differences as well as the requirements of our study (Fig. 3), (Fig. 4).

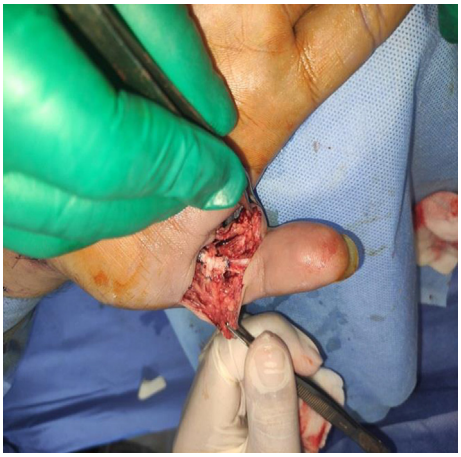

*Fig. 2. Two strands Kessler repair with non-absorbable Prolene 3/0 (**Group B**).*

Fig. 3. Four-strand cruciate repair in FDP left ring finger (zone II) after 3 months.

2.1. Methods of evaluations

To assess the clinical effectiveness of the repair and to document the results of finger flexor tendon

Fig. 4. Kessler repair in FDP right middle finger (zone II) after 3 months.

repairs, we relied on three factors; **Active range of motion**: if the contralateral hand is normal, comparing the values to what would be considered normal. We categorize a finger's active range of motion into five categories: excellent, good, fair, poor, and failure.

Grip strength When it is greater than the contralateral hand (the nondominant hand) or exceeds 70 % of the contralateral hand (the dominant hand), it was recorded as (+). Otherwise, grip strength is recorded as (−), which indicates that it is abnormal.

Quality of motion: It was evaluated based on in-person observation of finger motion during outpatient clinic visits. It is noted as 'excellent' when the motion arc, coordination, and speed all appear normal; as 'good' when any two of these three factors do; and as 'poor' when only one or none of these three factors appear normal.

Table 1. Demographica data of the patients.

	Total number = 20
Age (years)	
Median (IQR)	29 (20.5–36)
Range	7–44
Sex	
Female	6 (30.0 %)
Male	14 (70.0 %)
Dominance	
Nondominant	11 (55.0 %)
Dominant	9 (45.0 %)
Side	
Right	9 (45.0 %)
Left	11 (55.0 %)
Zone of injury	
Zone II	15 (75.0 %)
Zone III	1 (5.0 %)
Zone V	4 (20.0 %)
Number of fingers	
1	16 (80.0 %)
4	2 (10.0 %)
5	2 (10.0 %)
Special habits	
No	7 (35.0 %)
Yes	13 (65.0 %)
Smoking	13 (65.0 %)
Cannabis	8 (40.0 %)
Tramadol	5 (25.0 %)
Alcoholic	3 (15.0 %)

2.2. Data analysis

We used the Statistical Package for the Social Sciences (SPSS) version 20 (SPSS Inc., Chicago, IL, USA) to analyze our results. We compared the mean values between the two groups for the DIP, PIP, MCP joints active flexion. TAM and DASH score using parametric independent samples Student's t-test. We considered something significant when the probability value (p value) was less than 0.05.

3. Results

The active range of motion in addition to grip strength and quality of motion, which **Tang (2007)** used in his study, were the three factors on which we relied in the current study to evaluate clinically the quality of repair and to record the outcome of finger flexor tendon repairs.[10] Tables 1 and 2.

Results of evaluating active range of motion showed that 80 % of cases gained excellent to good active range of motion in **Group (A)** compared to 70 % of cases in **Group (B)**. It also showed that 20 % of cases obtained fair to poor results in **Group (A)** compared to 30 % in **Group (B)** Table 3.

Results of evaluating grip strength showed that 80 % of cases have positive grip strength in **Group (A)** compared to 70 % in **Group (B)** Table 4.

Results of evaluating Quality of motion showed that there was a statistically significant difference between the two groups regarding quality of motion. 70 % of patients in **Group (A)** recorded excellent quality of motion compared to only 20 % in **Group (B)**. While 10 % recorded as poor in **Group (A)** compared to 60 % in **Group (B)** Table 5.

3.1. The overall results

Group A: excellent to good in 80 % of patients (excellent 50 % and good 30 %), 1 fair 10 % (due to an infection started 5 days post operatively that

Table 2. Results of evaluation of the Motion range after repair of the studied groups.

Motion range after repair	Group A (Four-strand cruciate repair)	Group B (Two strand kessler repair)	Test value	*P* value	Sig.
	Number = 10	Number = 10			
Excellent	5 (50.0 %)	3 (30.0 %)			
Good	3 (30.0 %)	4 (40.0 %)	0.976[a]	0.807	**NS**
Fair	1 (10.0 %)	1 (10.0 %)			
Poor	1 (10.0 %)	2 (20.0 %)			

P value > 0.05: Non significant (NS); *P* value < 0.05: Significant (S); *P* value < 0.01: Highly significant (HS).

[a] Chi-square test.

Table 3. Results of evaluation of the Grip strength after repair of the studied groups.

Grip strength	Group A (Four-strand cruciate repair)	Group B (Two strand kessler repair)	Test value	*P* value	Sig.
	Number = 10	Number = 10			
Positive	8 (80.0 %)	7 (70.0 %)	0.267[a]	0.606	NS
Negative	2 (20.0 %)	3 (30.0 %)			

P value > 0.05: Non significant (NS); *P* value < 0.05: Significant (S); *P* value < 0.01: Highly significant (HS).
[a] Chi-square test.

Table 4. Results of evaluation of the Quality of motion after repair of the studied groups.

Quality of motion	Group A (Four-strand cruciate repair)	Group B (Two strand kessler repair)	Test value	*P* value	Sig.
	Number = 10	Number = 10			
Excellent	7 (70.0 %)	2 (20.0 %)			
Good	2 (20.0 %)	2 (20.0 %)	6.349*	0.042	S
Poor	1 (10.0 %)	6 (60.0 %)			

Table 5. The overall results.

Overall	Group A (Four-strand cruciate repair)	Group B (Two strand kessler repair)	Test value	*P* value	Sig.
	Number = 10	Number = 10			
Excellent	5 (50.0 %)	3 (30.0 %)			
Good	3 (30.0 %)	4 (40.0 %)	0.976*	0.807	NS
Fair	1 (10.0 %)	1 (10.0 %)			
Poor	1 (10.0 %)	2 (20.0 %)			

P value > 0.05: Non significant (NS); *P* value < 0.05: Significant (S); *P* value < 0.01: Highly significant (HS).

delayed the start of the rehabilitation protocol) and 1 poor 10 % (due to adhesions post operatively).

Group B: excellent to good in 70 % of patients (excellent 30 % and good 70 %), 1 fair 10 % (due to skin contracture) and 2 recorded as poor (due to adhesions).

Despite the overall results, but there was a significance difference in favor of **Group A** regarding the quality of motion i.e. motion arc, coordination and speed.

Group A: 70 % of patients had excellent quality of motion compared to only 20 % in **Group (B)**, While 10 % recorded as poor in **Group (A)** compared to 60 % in **Group (B)**.

4. Discussion

Despite extensive studies and increased understanding of flexor tendon anatomy, nutrition, biomechanics, healing, and adhesion formation, regaining adequate digital function after flexor tendon repair remains one of the most difficult goals in hand surgery.[11]

Many researchers looked into the connection between the circumferential epitendinous sutures' number of knots, number of loops, and number of strands and the strength of the repair. Tendon repair frequently involves one of the well-known modified Kessler techniques, which has the lowest gliding resistance compared to other suturing techniques.[12]

The more threads that cross the tendon repair area, the strongest the repair becomes. However, surgeons strive to reduce the technical challenges while maintaining the strength of tendon sutures.[13]

In order to determine the best method of treating flexor tendon injuries by gaining full range of motion, grip strength, and excellent quality of motion, we preferred to compare 4-strand core sutures with 2 strand core sutures in this study. We discovered that 70 % of patients who had 4-strand core sutures had excellent quality of motion compared to only 20 % of patients who had 2 strand core sutures.

These findings were consistent with a study by **Sandow *et al.***, who used a 4-strand suture technique and early active mobilization as part of their post-operative rehabilitation protocol. In their study, 52 patients with 73 tendon injuries underwent surgery. The same assessment method used in our study was used to grade 71 % of the repaired flexor digits as good or excellent, with 34 % of the repairs producing excellent results. The remaining 14 % of repairs were graded as fair, and the remaining 15 % as poor.[14]

Dawood also conducted a comparison study on 48 patients (114 digits) using the two strand Kessler

and the four-strand Cruciate techniques. Modified Kessler repair was used in 24 cases, or 50 % of them. 24 cases were repaired with a 4-strand cruciate (50 %). As opposed to the modified Kessler technique, which had excellent results in 45.8 % of cases, good results in 37.5 %, fair results in 12.5 % of cases, and poor results in 4.1 % of cases, the 4-strand cruciate repair had excellent results in 66.6 %, good results in 29.1 %, and fair results in 4.1 % of cases.[1]

Strengths aspects of the current study which might augment its internal validity include the following: Prospective interventional controlled single blinded study design, Matched patients groups, and Strict implantation of inclusion and exclusion criteria to avoid bias of including different pathological condition, i.e. in current study there were no patients who have high level of nerve injury or congenital hand anomalies.

4.1. Conclusion

In terms of motion range, grip strength, the zone of injury, and the likelihood of complications, this study indicates that flexor tendon injuries can be successfully managed by either two or four strands repair techniques. However, using a four-strand locked cruciate instead of a two-strand Kessler, then beginning early postoperative controlled active rehabilitation, leads to a better functional outcome, particularly in terms of motion quality, such as motion arc, coordination, and speed, as well as fewer complications.

Conflicts of interest

There is no conflict of interest in this study.

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