A COMPARATIVE STUDY OF TWO SUTURE CONFIGURATIONS IN ZONE II FLEXOR TENDON REPAIR IN ADULTS

A. M. Navali[1], A. R. Rouhani[1] and M. J. Mortazavi*[2]

1) Department of Orthopedic Surgery, Shohada Hospital, School of Medicine, Tabriz University of Medical Sciences, Tabriz, Iran

2) Department of Orthopedic Surgery, Imam Khomeini Hospital, School of Medicine, Tehran University of Medical Sciences, Tehran, Iran

Abstract- Although the increase in the number of core sutures during flexor tendon repair increases the tensile strength of the repair, both increased handling at the time of repair and increased bulk at the repair site have been hypothesized as affecting clinical outcomes by increasing gliding resistance. The purpose of our study was to assess whether increasing the number of core sutures from two strands to four strands in zone II flexor tendon repair could improve the clinical results. A total of 42 patients with 60 flexor tendon lacerations in zone II were enrolled in this study. The injured tendon randomly underwent surgical repair by using one of the 2-strand or 4-strand modified Strickland techniques. Postoperative rehabilitation was the active extension–rubber band flexion method of Kleinert in all patients. The average duration of follow up was 8 months. The mean total active motion was 155.16˚ in 2-strand group (excluding two ruptures) and 154.33˚ in 4-strand group ($P > 0.05$). Using Strickland's original score, this corresponds to excellent result in 83.3% and 86.6% of patients in 2-strand group and 4-strand group, respectively. Statistically, there was no significant difference between the clinical outcomes obtained in these groups. Concerning the tendon rupture after the repair, all of the ruptures (2 cases) occurred in the 2-strand group ($P > 0.05$). We concluded that both suture strength and gliding resistance have influence on the result of flexor tendon repair in zone II, and increasing the number of core sutures and the resulting suture strength may be negatively affected by increase in gliding resistance.

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Key words: 2- and 4-strand technique**,** flexor tendon repair, zone II

INTRODUCTION

There is a widely accepted belief that the lacerated flexor tendon should be mobilized with either passive or active flexion soon after repair to prevent contractures and the need for tenolysis (1-3). Although adhesion formation, one of the most severe complications following tendon repair, has been reduced by the use of early postoperative motion rehabilitation programs (4-7), tendon rupture, another important complication, still occurs (8-10). Modern suture repairs have increased the tensile strength of repair, but underestimation of forces in tendons and patients' noncompliance with instructions to avoid resistive active motion during rehabilitation may explain higher rupture rates in patients treated with early-active-motion protocols. On the other hand, many of the proposed suture configurations with high tensile strength are technically demanding (11-13), require excessive tendon manipulation, and increase the work of flexion which could adversely affect the final outcome (14).

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*** Corresponding Author:**
Seyed Mohammad Javad Mortazavi, Department of Orthopedic Surgery, Imam Khomeini Hospital, School of Medicine, Medical Sciences/University of Tehran, Tehran, Iran
Tel: +98 21 61192767
Fax: +98 21 66935512
E-mail: smjmort@yahoo.com

The purpose of the present prospective, randomized clinical study was to compare the clinical results of the locked two stranded suture repair and the locked four-stranded suture repair in zone II flexor tendon laceration, both of these techniques are suggested by Strickland (15,16).

MATERIALS AND METHODS

Patients with zone II flexor tendon injuries admitted to our hospital between September 2002 and August 2004 were randomized to be managed with either a locked two-stranded or a locked four-stranded suture repair. A separate blocked randomization procedure, based on random number generated by SPSS statistical package was used to assign the patient to one of two treatment groups.

Digits that were eligible for the study were those that had complete laceration of the flexor digitorum profundus tendon, with or without concomitant injury to the flexor digitorum superficialis in zone II of index, long, ring or little finger. Randomization was performed after it had been determined that the inclusion criteria had been met. Ethic's committee/institutional research board approval was obtained prior to the initiation of the trial. All patients enrolled in the study signed an informed consent form and were willing to return for required postoperative follow-up visit. After exclusions, 42 patients with 60 zone II flexor digitorum profundus lacerations and a mean age of 27 years (range, 18 to 55 years) entered the study. Exclusion criteria were crush injuries, lack of cutaneous coverage, a concomitant fracture or chondral lesion, amputated digit, extensor tendon injury at the same digit, arthritis of the hand, prior hand trauma, congenital hand defect, diabetes mellitus, autoimmune disorders and the use of medications that could affect postoperative wound healing. A fourteen-day cut-off was considered, and patients with injuries which have occurred within the fourteen days of admission were included in the study.

Single surgeon (AMN) performed all operations to maintain consistency. All procedures were performed under regional or general anesthesia and with similar surgical techniques. Tendons were approached through a modified Brunner incision with windowing of the tendon sheath. A2 and A4 pulleys were preserved as much as possible. The operative techniques for the two-stranded (Fig. 1) and four-stranded (Fig. 2) suture repair were shown as described by Strickland (15, 16). Depending on tendon size, all repairs were performed with a 4-0 or 5-0 Prolene® suture. In the four-strand group, an additional mattress core suture (4-0 Prolene®) with a purchase length 1-2 millimeters shorter than the first core suture was inserted in the palmar tendon gap. The repairs were completed in both groups with a single epitendinous 6-0 monofilament Prolene® suture in a running circumferential configuration. Concomitant injury to flexor digitorum superficialis tendon did not preclude the digit from being included in the study and did not affect randomization. According to surgical circumstances, flexor digitorum superficialis tendons were repaired in approximately 50% of cases in each group with modified Kessler technique using 4-0 or 5-0 Prolene®. In the remaining cases, the decision was made to repair only the flexor digitorum profundus and to leave the distal flexor digitorum superficialis tendon stump as a gliding bed for the tenorrhaphy and to maintain the vascular supply to the flexor digitorum profundus tendon.

Rehabilitation was started on the first postoperative day with a passive flexion and active extension protocol using a rubber band and a dorsal splint (Kleinert technique) (Fig. 3). After 3 weeks the splint was removed and the rubber band was attached to an elastic bandage around the wrist for an additional 3 weeks. The rubber band was discarded 6 weeks after surgery and the patients were then allowed to perform active flexion exercises.

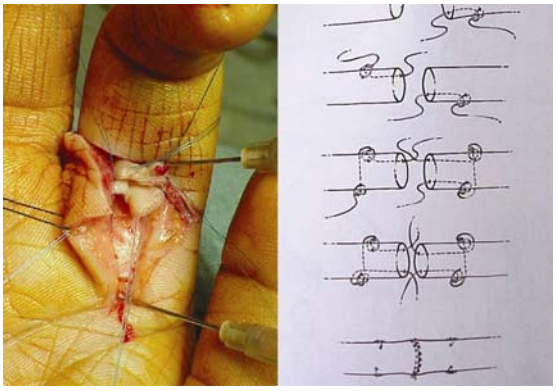

Fig. 1. Two-strand Strickland technique

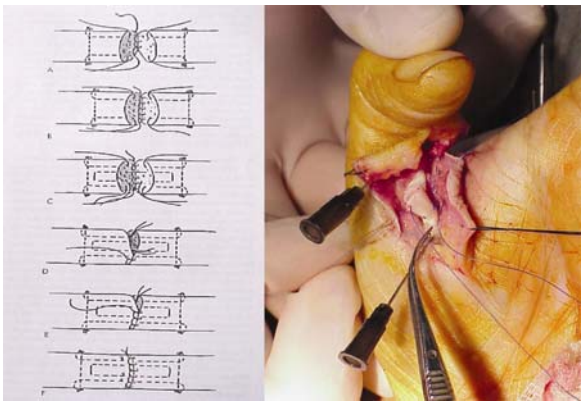

Fig. 2. Four-strand Strickland technique

Fig 3. Klinert rehabilitation method

The average duration of follow up was 8 months (range, 6-12 months). Postoperative assessments were performed by an independent examiner who was unaware of the repair type. Functional evaluation of all digits was performed taking into account the range of motion in flexion as well as the extension lag in the PIP and DIP joint using digital goniometer. Total active motion (TAM) was calculated by summing up the distal interphalangeal and proximal interphalangeal joints active flexion (15).

The percentage of normal PIP and DIP motion as then calculated using the Strickland's original equation: ([(Active PIP + DIP flexion) – (PIP + DIP extension deficit)]/175) × 100. Repairs were then classified as excellent (85% to 100%), good (70% to 84%), fair (50% to 69%), or poor (<50%) (15) (Table 1).

Statistical Methods

All statistical testing was done with SPSS package (version 11). A Student's *t*-test was performed to compare the mean active ranges of motion after the two-strand and four-strand repairs. Fisher's exact test was used to compare the rupture rates and outcomes in term of clinical grades. A *P* value of less than 0.05 was considered significant.

Table 1. Strickland's original Scoring

Rating	PIP + DIP Motion (%)
Excellent	85-100
Good	70 -84
Fair	50 - 69
Poor	<50

RESULTS

Forty-two patients out of 50 met the inclusion criteria with a total of 60 tendon lacerations. Thirty patients had involvement of only one digit, eight patients had involvement of two digits, two patients had involvement of three digits and in two patients four digits were involved. Thirty digits were randomized to each repair group. Sixteen digits in the two-stranded group and 18 digits in the four-stranded group had concomitant injury of the flexor digitorum superficialis tendon. Only about 50% of these concomitant lacerations were repaired in each group.

During postoperative period, two of the 30 tendons that were repaired with the two-stranded technique ruptured, whereas none of tendons in the four-stranded group sustained postoperative rupture (*P* value > 0.05). The range of active motion of proximal and distal interphalangeal joints after a mean of 8 months follow-up is shown in table 2. The mean total active motion was 155.16 degrees in the two-stranded group (with exception of two ruptures) and 154.33 degrees in the four-stranded group (*P* > 0.05).

Table 2. Mean active IP joint range of motion in degrees 6 to 12 months after operation- a comparison of 2-strand (n =28) and 4-strand (n = 30) techniques.*

	2-strand†	4-strand†
DIP	64.1±3.6	60.2±2.8
PIP	91.0±2.2	94.1±3.4
DIP + PIP	155.2±5.4	154.3±6.0

*Two ruptures in the 2-strand group are not included

† Values are expressed as mean ± standard error

Table 3. Results according to Strickland's original score

	2-strand No. of Digits (%)	4- strand No. of Digits (%)	*P* Value
Excellent	25 (83.3)	26 (86.6)	>0.05
Good	2 (6.6)	2 (6.6)	>0.05
Fair	1 (3.3)	2 (6.6)	>0.05
Poor (including rupture)	2 (6.6)	0 (0)	>0.05
total	30 (100)	30 (100)	

According to the Strickland's original score this means an average of 88% (range, 58-100%) of normal function in the two-strand and 88% (range, 52-100%) in the four-strand group which are compatible with overall excellent results. Table 3 shows the results according to the original Strickland scoring system (15). Statistical analysis shows no significant difference in the outcomes of these two groups in term of clinical grade (Fisher's exact test; P>0.05).

DISCUSSION

The technique of surgical repair for zone two flexor tendon injuries has been debated extensively through the years but adhesion formation, suture rupture, and suture locking on the pulley edge remain possible consequences of a poor repair (17). Although increasing the repair strength through increasing the number of strands crossing the repair site to allow active postoperative mobilization without increasing the risk of rupture is logical, it can compromise tendon gliding function. The increased handling of the tendon, particularly in inexperienced hands, increases adhesion formation which is a biological response to tendon damage and suture material and the increased number of strands increases the tendon bulk and surface irregularity which has mechanical implications on gliding function.

Clinical studies of flexor tendon repair have focused less on comparing repair techniques and more on methods of rehabilitation (14). Our study was performed to assess whether increasing the number of core sutures in flexor tendon repair in zone II improve the clinical results. There are a lot of studies addressing this subject performed in animals and in vitro models but to our knowledge, we performed the first randomized, blinded study in which two strand and four strand repair techniques are compared in a series of adult patients with the same rehabilitation protocol.

It is well accepted that core-suture techniques using a greater number of suture strands across the repair site result in a greater tensile strength than those with a similar pattern but fewer sutures across the repair site (18-20). Numerous studies performed on in vitro models involving commonly used core-suture techniques have demonstrated the superiority of the four-strand core suture over the two-strand core suture. In an in vitro model, Thurman *et al.* (21) found that the 2-strand repair had significantly greater gap formation after cyclic loading (mean gap, 2.75 mm) than either the 4-strand (0.30 mm) or 6-strand (0.31mm) repair. The tensile strength of the 6-strand repair (mean, 78.1N) was significantly greater than either the 4-strand (means, 43.0N) or 2-strand (mean, 33.9N) repair. Barrie *et al.* (22) in a biomechanical study using an in situ testing model demonstrated multi-strand repairs have greater tensile strength and gap resistance than 2-strand repair techniques.

The *in vitro* promise of multiple-strand suture techniques is not necessarily reflected in improved results *in vivo*. Several studies showed that many multi-strand techniques may have higher gliding resistance *in vitro* (23, 24). In a follow-up study adhesion formation in 2-strand modified Kessler and 4-strand Becker repairs were compared *in vivo* (25). The 2 suture techniques were chosen because they had relatively low (Kessler) and high (Becker) gliding resistance, respectively. Both groups had a passive postoperative mobilization program. The Kessler group was found to require significantly less force to break adhesions at 3 and 6 weeks after repair, leading the authors of that study to conclude that gliding resistance may be more important than suture strength, provided low-force passive gliding postoperative programs are used.

Our study investigated the effects of the number of core sutures in a clinical human model. This study showed that the 4-Strand as well as 2-strand

Strickland technique can produce similar excellent clinical results in more than 80% of cases, provided that they were applied properly with careful attention to details of atraumatic and delicate surgical technique and postoperative rehabilitation protocol.

Although all of the ruptures (2 cases) occurred in the 2-strand group, our data was not enough to attribute this finding to the type of repair techniques so it needs other study with a lager number of cases to determine whether this is due to repair technique or to other confounding variables.

Thus we can conclude that both suture strength (affected positively by the number of core suture) and gliding resistance (affected negatively by the number of core suture), should have been taken into account when using different suture techniques in the repair of flexor tendons in zone II, and although increasing the number of core sutures results in increase of the suture tensile strength, so it may negatively influence the clinical outcome by increase in the gliding resistance.

Conflict of interests

The authors declare that they have no competing interests.

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$$\frac{(PIP+DIP)flexion-(PIP+DIP)extension\ \ deficit\times 100}{175}=\%of\ \ \ normal\ \ active\ \ PIP+DIP\ \ motion$$