

Prevention of Restrictive Peritendinous Adhesions in Flexor Tendon Repair with Autologous Transplanted Vein Graft

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ABSTRACT

This study was done to assess the technique of wrapping the hand flexor tendon repair with autogenous vein graft to prevent post-operative peri-tendinous adhesions which affect the repair success. Nine patients (6 male patients and three female patients) were seen between January 2005 and January 2008 in Cairo University hospitals and Health Insurance hospital. The age of the patients participating in the study ranged from 17 and 36 years. Those 9 patients were selected among the cases of flexor tendon injury coming to the hospital in whom the tendon sheath was cut or one of pulleys was destroyed so that the repair of the tendon was liable to post operative adhesions. Four of the patients presented with failed primary repair of their flexor tendon injury. Two cases were delayed primary repair of undiagnosed flexor tendon injury. The last three cases were cases of fresh trauma to the hand in zone II with lacerated flexor tendon and loss of the tendon sheath and pulley system at the site of injury. Two patients escaped follow-up. So the study included only 7 patients which completed the follow up period. All repairs were done by the modified Kessler technique. Before reaching the step of tendon repair part of the Long Saphenous vein was harvested. The vein graft segment is wrapped around the tendon in a way so that the smooth intima is facing the paratenon. This vein graft segment is considered as a replacement of the tendon sheath in which the tendon is gliding. Post-operative Program of active mobilization. The patient performed active finger mobilization. The fingers were initially mobilized with the wrist splint in place. The mobilization programme comprised gentle flexion of the interphalangeal joints followed by gentle slow extension and then the patients were instructed to relax to allow passive recoil of the fingers back to resting position. This cycle of movement was repeated slowly with time breaks in-between. The range of flexion as well as the number of movements and sessions were gradually increased according to the condition and progress of the patient.

All patients were assessed using the total active motion (TAM) scoring Final assessment after a follow-up period of 6 months revealed excellent range of movement in two cases, good range of movement in 3 cases and fair result in 2 cases.

So the use of autologous vein graft as a replacement of tendon sheath has many advantages like; it is not expensive, being autologous so not carrying the risk of infection, also it will not affect the tendon healing like other materials. It is not only used to treat post-operative tendon adhesions but

also can be used as prophylactic procedure in cases of lost tendon sheath in fresh cases. It also improves tendon nourishment. After studying this technique in a multi-centre study and comparing it to the conventional tendon repair, it can be added as a routine step in cases of tendon injury in which we are expecting adhesion formation.

INTRODUCTION

Tendons are anatomical structure that helps the movement of fingers.

The main goal of flexor tendon surgery is to restore digital motion by providing tendon healing and preserving tendon gliding [11]. The formation of peritendinous adhesions around the repair site is one of several adverse events that may prevent achievement of this goal [2,8].

The restoration of an injured digital flexor tendon to a functional state after its repair within the digital sheath remains a major problem. Two complications that can prevent active flexion of the finger may occur: One is breakdown of the suture and the other is adhesions in the digital canal around the tendon repair. Recent concepts of tendon nutrition and healing stressed on the diffusion of nutrients via the synovial sheath, which may be injured either by trauma or by the surgeon doing the repair [10,19].

The most important element in the motion of the tendons is gliding in the synovial sheath which is present at the proximal 1/3 of the tendon [5,13]. The most severe complication of the treatment of inflammatory and traumatic tendinitis is the adhesion of the tendons, between each other and with their clefts or with the neighbouring tissues while they are treated medically or surgically or even left without treatment [15]. Many investigations for the prevention of postoperative adhesion of tendons have been done.

Some investigators have done tenoraphy operations on the avian extensor tendons, either repaired the tendon alone or repairing the tendon and then repairing the synovial sheath. In this experiment, histopathologically smooth and slippery structure and orderly proliferation of the fibroblast in the group where the tendon and its sheath were repaired. They have also reported to observe disordered fibroblast proliferation, low collagen construction and the adhesion between peritendons 8 weeks after the operation in which only tendons were repaired [17].

Others have investigated the effects of Na-hyaluronate and methylcellulose injection on the adhesion of tendons. They have concluded that Na-hyaluronate is more effective than methylcellulose in the prevention of the adhesion [1,17].

In a study, the effects of triamsinalon (0.05mg) and Na-hyaluronate (1%) on the recovery from tendonitis has been compared [15]. Following 3 weeks immobilization of the extremities, there weren't many differences between the two groups in terms of recovery. However, triamsinalon had no effect on the adhesion while Na-hyaluronate had reverse effect in addition to less inflammatory cells, less intratendinous and peritendons bleeding and less scar tissue.

Some surgeons used hydroxyapatite artificial sheath and alumina artificial sheath in different groups in order to disconnect the tendon from the adjacent tissue. In this study, the authors speculated that it is very important to separate the repaired tendons from adjacent tissues with a barrier in recovering period [16,19].

Autologous saphenous vein graft has been used for the prevention of the adhesion of tendons [15].

In case of loss of a segment of the tendon either due to trauma or undiscovered injury of the tendon at the time of trauma, there will be many adhesions around the supposed place of the tendon repair. Repair can be done in 2 stages the first one was to put silicone rod in the site of lost segment. During a period of 10 weeks a new lining forms around the silicone rod. In the second stage the repair or tendon graft is done through this new artificial lining [20].

Özgenel studied the effects of a combination of hyaluronic acid injection around the tendon repair site and amniotic membrane wrapping around the repair on the formation of peritendinous adhesions after flexor tendon surgery in chickens [18].

Mobilization following flexor tendon repair is essential for healing and repair and it has been shown experimentally that early motion stimulates tendon healing and decrease adhesions [11]. Kleinert was among the first to report remarkable clinical results using active extension-passive flexion mobilization with the aid of a dynamic traction splint. However flexion contracture of the finger may develop and it has been difficult to achieve flexion of the distal interphalangeal joint. So active mobilization of the injured finger will solve these problems because it provides differential gliding between the tendons in a physiological manner [6,7].

In this study the use Autologous vein graft wrapped around the tendon repair site was studied to show the effect on formation of tendons adhesion and the movement of these fingers after the repair.

PATIENTS AND METHODS

Nine patients (6 male patients and three female patients) were seen between January 2005 and January 2008 in Cairo University hospitals and Health Insurance hospital. The age of the patients participating in the study ranged from 17 and 36 years. All these patients suffered flexor tendon injury. Those 9 patients were selected among the cases of flexor tendon injury coming to the hospital in whom the tendon sheath was cut or one of pulleys was destroyed so that the repair of the tendon was liable to post operative adhesions. The patients included in the study were those with pulley incompetence, extensive scarring or failed primary repair. Four of the patients presented with failed primary repair of their flexor tendon injury. Two cases were delayed primary repair of undiagnosed flexor tendon injury, these 2 patients required tendon grafts due to contraction of the musculo-tendonous unit making it difficult to pull the tendon out to its proper length. The last three cases were cases of fresh trauma to the hand in zone II with lacerated flexor tendon and loss of the tendon sheath and pulley system at the site of injury. For those last cases the repair was expected to be surrounded with adhesions so a vein graft wrapping around the repair was decided from the start. The patients were followed-up for a period of six months. Two patients escaped follow-up.

So the study included only 7 patients which completed the follow-up period.

The site of tendon injury was zone III in Five cases and in zone II in two cases. The patients presented by minimal movement of the affected finger either due to severe adhesion around the previous repair or due to undiagnosed tendon injury

and the minimal movement is by the non affected deeper flexor tendon (FDP tendon) or flexion by the lumbricals.

The repair of these tendons was wrapped by an autologous vein graft to cover the suture line and prevent post-operative adhesions. Then evaluation of the repair as regard the range of movement of the affected finger was reported.

Surgical technique:

The patient is placed in a supine position. The patient's arm should not be over-abducted avoiding strain on the brachial plexus. Direct attention should be paid to the position and padding of the elbows to avoid the difficult problem of post-operative ulnar neuritis. The hand is best supported on a hand stand. A good light source should be available. Magnification operating loupes of 2X was used. The patient was operated upon under general anesthesia. An arm pneumatic tourniquet was used to work in dry clean bloodless field (pressure of 250mg or 70mg above the systolic pressure). A zigzag incision is used. The site of tendon injury is looked for and recognized. The two ends of the tendon should be explored the proximal and the distal ends. In case of untreated old tendon injury, the proximal end may not be able to reach the distal one. In this case a tendon graft was used from the palmaris longus tendon. In case of failed

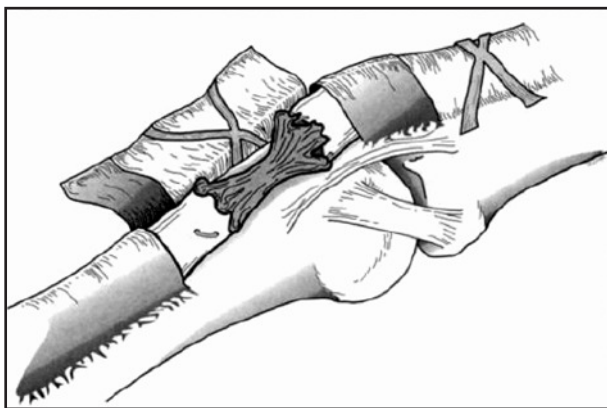


Fig. (1): Elongation of tendon repair [8].

Post-operative program of active mobilization:

The hand was put in a dorsal splint to prevent severe extension of the finger which may rupture the repair early in the post-operative period. The dorsal slab maintains the wrist in 40° flexion and extension block of the metacarpo-phalangeal joints at 90°. This splint was changed from the 3rd post-operative day to be 40° at the wrist and 70° at the metacarpo-phalangeal joint and dorsal extension block for the fingers at 0°. The fingers were unobstructed and able to move freely.

primary tendon repair exploration of the site of previous repair is done. Release of adhesions around both ends of the tendon (tenolysis) is performed. After tenolysis of old repair we either found a weak repair which should be revised or a good strong one will be wrapped with the vein. In our cases we revised the entire previous repair. All repairs were done by the modified Kessler technique. Before reaching the step of tendon repair the assistant is harvesting part of the Long Saphenous vein above the medial malleolus as shown in Fig. (3b,c). The vein graft is threaded over the proximal or distal part of the tendon. Then a Modified Kessler repair is done by a 2-strand core suture with Prolene 4/0 on a rounded needle. This is combined with a peripheral epitendon suture (Prolene 6/0 rounded) to provide smooth outer gliding surface. Then the vein graft is slide to cover the segment of tendon repair plus part of the proximal and distal tendon Fig. (3d,e). The vein graft segment is wrapped around the tendon in way so that the smooth intima is facing the paratenon. In this way no adhesions will be formed around the repair and the tendon will glide in a smooth tunnel (the vein). This vein graft segment is considered as a replacement of the tendon sheath in which the tendon is gliding. The last step was closure of the wound without closing so many layers over the repair to minimize adhesions formation.

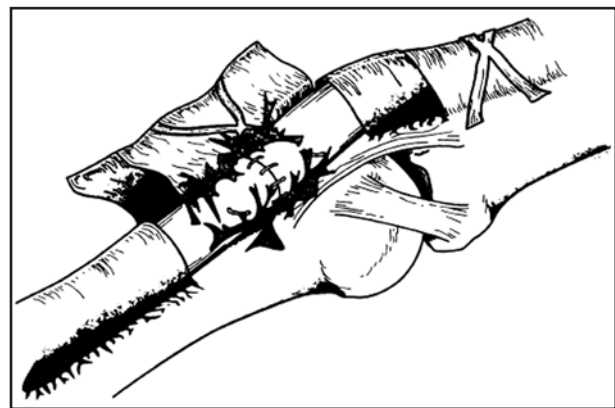


Fig. (2): Peri-tendinous adhesions [8].

The patient performed active finger mobilization. The fingers were initially mobilized with the wrist splint in place. There was normally 30°-40° flexion of the interphalangeal joints at rest. The mobilization programme comprised gentle flexion of the interphalangeal joints from this resting position for a further 20 (flexion range, 30°-50°) followed by gentle slow extension to 0° (full extension) and then the patients were instructed to relax to allow passive recoil of the fingers back to resting position. This cycle of movement was

repeated slowly with time breaks in-between. The number of movements was usually 5 times of 2 to 3 sessions on the first day. The range of flexion as well as the number of movements and sessions were gradually increased according to the condition and progress of the patient.

On the post-operative day 7-10, a "flex and hold" technique was added. All the patient's fingers were first gently flexed into the palm and the patient's hand held in a fist. The wrist was gently extended and once this position was achieved, the patient was told to hold the grip.

This maneuver encourages active contraction of the flexors with minimal resistance. Patients were discharged after having mobilization programme and were advised some precautions including avoidance of vigorous exertion and dependency of the hand. The patients were requested to return for daily physiotherapy for 2 weeks. In week 4, the dorsal splint was changed to a neutral wrist splint and progressive resisted mobilization was added. After 6 weeks resisted mobilization aimed at building muscle strength was commenced and passive stretching or splinting was applied if there was flexion contracture or stiffness.



Fig. (3-A): Exploring the proximal and distal ends of the tendon.



Fig. (3-B): The Saphenous vein after harvesting.



Fig. (3-C): Dilating the vein.



Fig. (3-D): Passing the vein into one end of the tendon.



Fig. (3-E): The repair completed and the vein is on the distal end.



Fig. (3-F): Sliding the vein to cover the repair.

Table (1): Patients who completed follow-up.

	Age	Gender	Presentation	Type of repair	Zone of tendon injury	Tendon Injured
Case 1	22	Male	Failed primary tendon repair	Primary tendon repair	Zone III	FDS
Case 2	30	Female	Failed primary tendon repair	Primary tendon repair	Zone III	FDS
Case 3	17	Male	Fresh trauma	Primary tendon repair	Zone II	FDS & FDP
Case 4	27	Male	Failed primary tendon repair	Primary tendon repair	Zone III	FDS
Case 5	32	Male	Undiagnosed at the time of trauma (delayed)	Tendon graft	Zone III	FDS & FDP
Case 6	36	Female	Fresh trauma	Primary tendon repair	Zone II	FDS
Case 7	19	Male	Undiagnosed at the time of trauma (delayed)	Tendon graft	Zone III	FDS

FDS → Flexor digitorum superficialis. FDP → Flexor digitorum profundus.

RESULTS

Seven cases of flexor tendon injury were treated surgically during 3 years period. Those cases of flexor tendon injury was 5 cases in zone III and 2 cases in zone II. After doing the tendon repair (which was Modified Kessler technique in our cases), it was wrapped by a segment of the saphenous vein. It was intended to put this vein graft segment around the repair or tendon graft anastomosis to prevent post-operative adhesions. Formation of these adhesions will hinder the gliding effect of the tendon, thus making the movement of the related finger difficult.

The post-operative physiotherapy program was active mobilization technique. The patient performed active finger mobilization. The fingers were initially mobilized with the wrist splint in place. The mobilization programme comprised gentle flexion of the interphalangeal joints from

this resting position for a further 20 (flexion range, 30°-50°) followed by gentle slow extension to 0° (full extension). The range of flexion as well as the number of movements and sessions were gradually increased according to the condition and progress of the patient.

Assessment:

All patients were assessed using the total active motion (TAM) scoring system of the American Society for Surgery of the Hand (Table 2). Assessments were carried out at 3, 6, 9 and 12 weeks postoperatively and a final assessment performed after a minimum of 6 months. The power grip and pinch grip were also measured at the same time.

Final assessment after a follow-up period of 6 months revealed excellent range of movement in two cases, good range of movement in 3 cases and fair result in 2 cases.

Table (2): Total active motion (TAM) scores of the American Society for Surgery of the Hand* [6].

Grade	TAM score
Excellent	100% normal
Good	75-99% normal
Fair	50-74% normal
Poor	<50% normal

Table (3): Final range of movement after follow-up period of 6 months.

TAM grade	No. of cases of 7 cases
Excellent	2 Cases
Good	3 Cases
Fair	2 Cases
Poor	—

DISCUSSION

The methods for reconstruction of flexor tendons are primary tendon repair, delayed direct repair, one stage flexor tendon grafting, or two-

stage flexor tendon grafting (using preliminary silicone rod spacer).

The main goal of flexor tendon surgery is to restore digital motion by providing tendon healing

and preserving tendon gliding. The formation of peritendinous adhesions around the repair site is one of several adverse events that may prevent achievement of this goal [1,4].

After failed primary flexor tendon surgery, the surgeon must keep in mind that a failed reconstructive procedure such as a tenolysis may then need to be followed by a two-stage flexor tendon grafting. In some patients all this adds up to a costly and often worthless exercise.

So the available known methods of treating post-operative tendon adhesions are either tenolysis, tendon grafting, or two-stage tendon grafting using preliminary silicon rod spacer.

Flexor tendon injuries occur frequently and are associated with many complications even after surgical repair. Despite the improvements in surgical techniques and rehabilitation programs, adhesions between the tendon and its sheath are the most common complication after tendon repair. Restricted motion caused by adhesions around the repair site interferes with the tendon gliding, which results in contracture and decreased range of motion of the digit [1]. For this reason, many studies have examined biological or synthetic materials such as autogenous vein and fascia graft [12,15,20] amniotic membranes [3,18] silicone sheeting [6] polytetrafluoroethylene surgical membranes [5] and Seprafilm [13]. Other studies have evaluated the use of biochemical agents such as corticosteroids [9] hyaluronic acid [1] indomethacin [21] and 5-fluorouracil [14] for reducing peritendinous adhesions.

One of the post operative complications of tendon repair is inability to move the digit properly due to the formation of peri-tendinous adhesions. So it was very important to prevent the formation of these adhesions from the start. Some precautions were used during repair to prevent those adhesions like; gentle handling of the tendon ends, keeping the paratenon intact, avoiding much dissection around the tendon to keep its blood supply, good hemostasis to prevent hematoma formation, also the fine 6/0 prolene repair layer after taking the core suture to make the tendon suture line smooth from outside. Those were some of the rules which should be followed to prevent adhesion formation.

Menderes, et al studied in 30 rabbits Seprafilm which was used for the prevention of peritendinous adhesions following flexor tendon repair. Seprafilm Bioresorbable Membrane (Genzyme Corporation, Cambridge, MA) contains sodium hyaluronate and

carboxymethyl cellulose [13]. They concluded that in rabbit the peri-tendinous adhesions following flexor tendon repairs could be lowered with Seprafilm and hyaluronic acid. Small et al., showed the benefit of early mobilization following flexor tendon repair in zone II [7].

Moran et al., studied the effect of a single intra operative application of 5-FU at concentrations of 25mg/mL appears to be an effective mechanism for reducing postoperative flexor tendon adhesions [14].

Muhittin et al., in their study suggested that suramine (a known inhibitor of transforming growth factor β) decreases adhesions after flexor tendon repair. At the same time, it also may decrease the tendon strength as dose-dependent. They also suggested future studies which should be performed with a variety of doses to determine the appropriate dosage for clinical application [16].

In our study the use of autologous vein graft as a substitute for the destroyed tendon sheath was evaluated. This was followed by a post-operative program of physiotherapy to aid in prevention of these peritendinous post-operative adhesions. Our results was encouraging giving a n excellent and good post-operative range of movement in 5 out of seven cases who completed the follow-up period for at least 6 months.

Other methods mentioned above used to prevent post operative adhesions are either expensive, or affect healing beside preventing adhesions formation. Some of the synthetic materials may decrease blood supply reaching the area of repair which is not present when using the vein graft as blood will reach by diffusion. It is known that the mechanisms of wound healing are closely related to tendon adhesions so, as mentioned some materials like Suramine decreases adhesion formation and also some affection of tendon healing.

Some normal autologous substances like amniotic membrane or fascia should be compared with vein graft on wider scale with studies on a larger number of patients.

So the use of autologous vein graft as a replacement of tendon sheath has many advantages like; it is not expensive, being autologous so not carrying the risk of infection, also it will not affect the tendon healing like other materials. It is not only used to treat post-operative tendon adhesions but also can be used as prophylactic procedure in cases of lost tendon sheath in fresh cases.

Conclusions:

Results of this study appeared encouraging when compared with the outcomes achieved by the conventional tendon repair technique. As this technique reduces the adhesion formation, improves tendon nourishment and decreases the need of intensive physiotherapy, it may substitute the conventional one and become a standard technique in the future. Also it can be cheaper and easier technique in preventing post-operative peri-tendinous adhesions if compared with other conventional methods. So the combination of this new technique with the early mobilization after tendon repair will add to minimizing adhesions and improving the results of tendon repair.

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