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ORIGINAL PAPER

Prevention of peritendinious adhesions in zone II primary flexor tendon repair using a vein patch graft: A comparative study

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Abstract

Background Adhesion after intrasynovial tendon injury is a major clinical problem. Here we assess autogenous vein graft over the primary flexor tendon repair to prevent postoperative peritendinious adhesions.

Methods Twenty-six patients (30 digits) had an acute flexor tendon injury in zone II. Primary tenorrhaphy was done using the traditional Kessler repair technique. Patients were divided into two groups according to the management of tendon sheath defects. In group I ($n = 15$ digits), a patch of a marked forearm vein was harvested, divided and sutured to the tendon sheath window. In group II ($n = 15$ digits), the tendon sheath was left untreated. Patients were evaluated using the second Buck-Gramcko scale at 8 weeks and 6 months.

Results We detected no statistically significant difference between the groups. For the vein graft group, excellent results were achieved in four digits, five digits with very good results, five digits with good results and one digit with fair results. Using the traditional technique, excellent results were achieved in three digits, very good results were achieved in four digits, good results were achieved in six digits and fair results were achieved in two digits.

Conclusions The use of autologous vein graft has many advantages; it is inexpensive, autologous and will not affect tendon healing. Comparing autologous vein graft to the conventional tendon repair technique, we detected no statistically significant difference. Clinically, less adhesion formation and fewer joint contractures were noted when using the autologous vein graft.

Level of Evidence: Level I, therapeutic study.

Keywords Hand · Flexor tendon · Finger · Plastic surgery · Trauma

Introduction

The repair of zone II flexor tendons is difficult because the healing tendon adheres to its fibro-osseous tunnel. This was termed "no man's land" by Bunnell (1948) due to the poor outcome in the range of motion (ROM) following tendon repair [1]. Many approaches have been suggested to improve repair outcomes, including stronger surgical repairs, appropriate pulleys or sheath management, optimisation of rehabilitation regimens and modern biological approaches [2].

Adhesion formation after intrasynovial tendon injury represents a major clinical problem. Disruption of the synovial sheath allows surrounding granulation tissue to invade the repair site, resulting in adhesion formation. It is logical to re-establish the continuity of the tendon sheath to improve tendon nourishment and prevent restrictive adhesion formation that might occur between the repaired tendon and surrounding tissues [3].

The advantages of sheath repair include the following: serving as a barrier to the formation of extrinsic adhesions, provision of a quicker return of synovial nutrition, acting as a mould for the remodelling tendon and better tendon–sheath biomechanics [4].

Experimentally, several techniques have been described for primary reconstruction of the tendon sheath defects using various autogenous and synthetic materials. Eiken et al. used the tendon sheath graft. Biro et al. used an autologous vein graft.

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Peterson et al. used a facial patch graft. Hanff et al. reported the role of polytetrafluoroethylene. Oei et al. reconstructed a tendon sheath using a parietal peritoneum or a processed porcine collagen membrane [4–8]. Clinically, autogenous vein graft has been used to prevent the adhesion of tendons [3, 9–11].

In this study, we aim to evaluate the role of an autogenous vein graft in the prevention of postoperative peritendinious adhesions. This was done by comparing the functional outcome of flexor tendon repair in zone II with or without vein grafting of the flexor tendon sheath defects.

Patients and methods

This prospective randomised clinical trial was made during the period from October 2014 to January 2017. It included 26 adult patients (age from 15 to 29 years) with acute, sharp injuries in both the FDS and FDP tendons in zone II.

Thirty fingers were tested. Twenty-two patients had an isolated injury, and four patients had injuries in two adjacent digits. Patients with concomitant fractures, bilateral neurovascular injuries, injured extensor mechanism, heavy skin laceration with skin loss, thumb injuries and cases of tendon avulsion were excluded from the study.

After the primary survey, a thorough patient history was taken, including detailed clinical examination. Patients were exposed to routine hand X-ray to exclude associated fractures or foreign bodies. Patients received intravenous antibiotics and anti-titanic serum immediately. Below the elbow, a dorsal blocking splint was applied to avoid further retraction of the tendon ends until the operation. Patients were operated within 24 h of admission.

Preoperatively, patients were simply randomised and divided into two groups. Written informed consent for participation was obtained from all participants who had also given informed consent for approval of publication of photographs.

Operative procedure

Under general anaesthesia, with a pneumatic tourniquet control, the wound was explored, and the flexor sheath was explored for injury. In all fingers, tendons were explored and retrieved by central venting of the flexor sheath at the site of injury. Some tendons needed an opening of the flexor sheath at sites of cruciate pulleys to deliver the retracted tendon ends.

Tenorrhaphy was done for both tendons starting with 4–0 polypropylene, double-strands, modified, Kessler locking suture for both FDP and FDS tendons. Repairs were reinforced by 6–0 polypropylene, locked, running, epitendinous suture.

After tenorrhaphy, according to the management of tendon sheath defects, the repair was divided into two groups. In group I, the tendon sheath was reconstructed by a vein patch. In group II, we repair the tendons only, as follows:

In group I ($n = 15$ digits), following tenorrhaphy, repair of the defect in the tendon sheath over the tendon repair site was made using a vein patch graft harvested from a sizable forearm vein. A sizable donor vein was identified and marked before the application of the arm tourniquet. After making a 30-mm skin incision, ligation of both ends of the vein was done, then the 15 to 20 mm from the vein was harvested. The vein graft was preserved in an isotonic saline until the tendon repair was completed.

The vein graft was carefully dilated using a blunt-tipped haemostat (care taken to avoid intimal injury). The vein graft was incised longitudinally and used as a patch over the tendon sheath defect at the repaired site (10 × 15–20 mm patch according to sheath defect size).

The vein graft was stitched with 7/0 polypropylene, continuous, running sutures to the sides and proximal and distal ends of the sheath defect. The endothelial surface of the vein graft faces the tendon repair site (Figs. 1 and 2). An intra-operative gliding test was done to avoid triggering repair at the sheath repair site.

Following skin closure, a dorsal blocking splint was applied below the elbow, with the wrist flexed 15–30°, the metacarpophalangeal (MCP) joints in 55 to 70° flexion and IPs extended.

Patients were exposed to a controlled passive rehabilitation program. The postoperative assessment was done after the first 8 weeks and, finally, at 6 months. The Buck-Gramcko II scale was used to assess the outcome [12] (Table 1). This method measures the composite flexion, pulp to palm distance, the total ROM and extension deficit by using a 180°short-arm goniometer (Fig. 3) and measuring ruler (Fig. 4).

Results

Twenty-six adult patients underwent primary repair of cut FDP and FDS tendons in zone II with an acute, sharp injury. All patients completed the final follow-up period of 6 months. No patient escaped or was excluded from the study.

Data analyses were done using an IBM computer and SPSS 16 (statistical program for social science version 16). Patient demographics are presented in Table 2.

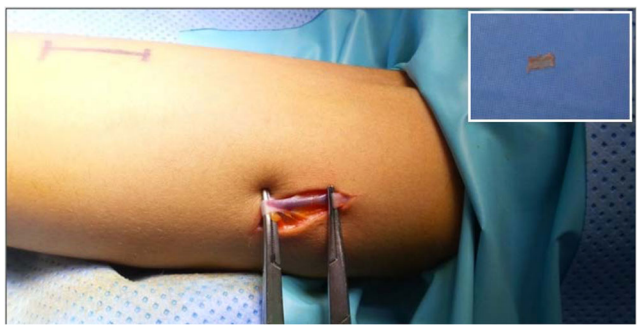

Fig. 1 Photograph showing: harvesting medial forearm vein graft (small photo showed vein patch graft)

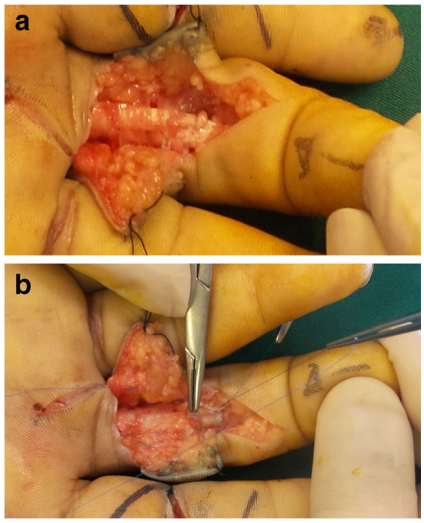

Fig. 2 **a** Photograph showing tendon sheath defect following repair of both FDS and FDP. **b** Photograph showing repair of tendon sheath defect using vein patch graft

Regarding the Buck-Gramcko assessment, we detected no statistically significant difference between the groups (Table 3).

At 8 weeks, group I showed good results in three digits, fair results in ten digits, poor results in two digits and no excellent or very good results. While group II showed good results in three digits, fair results in nine digits, poor results in three digits and no excellent or very good results (Table 4).

At 6 months, group I showed excellent results in four digits, with very good results in five digits, good results in five digits, fair results in one digit and no poor results. Group II showed excellent results in three digits, very good results in four digits, good results in six digits, fair results in two digits and no poor results (Table 5 and Fig. 5).

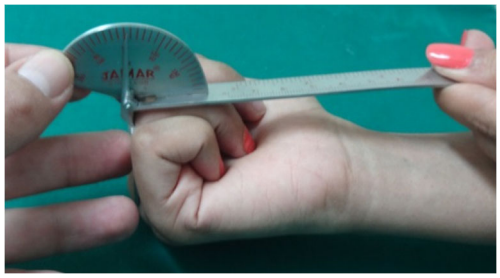

Fig. 3 Photograph showing measuring active flexion R.O.M using a short-arm goniometer

Five digits out of the 30 operated digits developed complications (16.6%). Three complications (10%) required re-operation.

Group I included one case of late repair rupture (5th-week post-repair). Immediate re-repair was done, and the patient was again included in the controlled passive rehabilitation program. No other complications were noticed, such as restrictive adhesions or joint contractures.

Group II included two cases of joint contractures, and two patients had tendon adhesion. No other complications (e.g. repair ruptures) were reported (Table 6).

Discussion

The main goal of flexor tendon surgery is to restore digital motion by providing tendon healing and preserving tendon gliding. The formation of peritendinious adhesion around the repair site is one of the most common adverse effects that might prevent achievement of this goal [9, 13, 14].

The concepts of tendon nutrition and healing have changed, and an emphasis is now placed on the role of nutrient diffusion from the synovial fluid for the nourishment of flexor tendons.

Table 1 The second Buck-Gramcko method of assessment (fingers–zone II)

Buck-Gramcko II		
Fingernail to distal palm crease	0.0–0.5	6 points
	0.6–1.5	5 points
	1.6–2.5	4 points
	2.6–4.0	3 points
	4.1–6.0	2 points
	> 6.0	0 points
Total extension lag (MCP + PIP + DIP)	0°–30°	3 points
	31°–50°	2 points
	51°–70°	1 point
	> 70°	0 points
Modified total active motion (MCP + 2 × PIP + 3 × DIP)	> 400°	8 points
	> 320°	6 points
	> 280°	4 points
	> 240°	2 points
	< 240°	0 points

Excellent, 16–17 points; very good, 14–15 points; good, 11–13 points; fair, 7–10 points; poor, 0–6 points

Fig. 4 Photograph showing measuring fingernail to palm distance using a ruler

Theoretically and experimentally, tendon sheath reconstruction establishes an environment in which diffusion and tendon nutrition can take place. So, adhesion formation between the newly repaired tendon and adjacent tissues would be prevented [3, 15, 16]. Furthermore, unrepaired window or laceration in the sheath, scars and adhesions might be formed, thus limiting the ROM [17].

According to the literature, to date, autologous tissues (such as fascia lata, free tendon grafts, vein grafts or extensor retinaculum) have been used for sheath reconstruction [3, 10, 18–22]. These studies have demonstrated the proliferation of a new gliding surface [23, 24].

In the reported clinical series, there have been few reports about autogenous vein grafts for repair of the tendon sheath defect. Nevertheless, results have been optimistic and encouraging. For this reason, we studied the role of primary tendon sheath repair with a vein patch graft in the prevention of peritendinious adhesion. We compared the functional outcome of flexor tendon repair in zone II with or without vein graft.

In our study, we found that in group I, excellent results were achieved in four of 15 digits (26.7%), while very good results were achieved in five digits (33.3%), good results were achieved in five digits (33.3%), fair results in 1 digit (6.6%) and no poor results. In group II, excellent results were achieved in three digits (20%), very good results in four digits (26.7%), good results in six digits (40%), fair results in two digits (13.3%) and no poor results. We detected no statistically significant differences between the tested groups.

In our study, excellent results were achieved in four (26.7%) of 15 digits. This finding is similar to that reported by Sakr and Ahmad, who reported 28.6% excellent results. These authors studied the vein graft technique in seven patients; results were excellent in two cases (28.6%), good in three cases (42.8%) and fair in two cases (28.6%). These authors studied primary and delayed primary repair of cut (either FDP and FDS or FDP tendons) in zone II or III. In some cases, the vein graft was enveloped around the tendon repair, and in the other cases, the authors used a vein patch graft over the tendon sheath defect. The TAM method of assessment was used for evaluation [9].

Table 2 Comparison between both groups as regard general data

Variables	Group 1 15 = *N*	Group 2 15 = *N*	*t*	*P*
Age	22(SD 3.5)	20.4(SD 3)	0.9	0.67 NS
Gender			Fisher	0.19 NS
Male	13(86.7%)	10(66.7%)		
Female	2(13.3%)	5(33.3%)		

Table 3 Comparison between values in both groups as regard Buck-Gramcko scale of assessment

Variables	Group1	Group 2	*t*	*P*
After 8 weeks	8.4 (SD 2.6)	8.5 (SD 2.2)	0.07	0.94 NS
After 6 months	13 (SD 4)	12.8 (SD 3)	0.17	0.86 NS

Mousavi et al. studied the vein graft technique in 105 patients, reporting excellent results in 90 patients (86%), good results in 12 (11%), fair results in three (3%) and no poor results. This study was used for primary repair of cut (either FDP and FDS or FDP tendons) in zone I or II. No age group was specified. Some cases had an associated skin loss that needed debridement and delayed primary repair; we excluded these cases in our study. In some cases, the vein graft was enveloped around the tendon repair, and the author used a vein patch graft over the tendon sheath defect with the others. The results were graded according to the return of the ROM at the MCP joints [3].

El Banna and Abdel-Meguid studied the vein graft technique in ten patients in zone II; results were excellent in nine cases (90%) and good in one case (10%), with no fair or poor results. Some cases had associated fractures. The authors did not specify the injuries of FDP or both FDP and FDS tendons. In some cases, the vein graft was enveloped around the tendon repair, and the authors used a vein patch graft over the tendon sheath defect with the others. Finally, the authors used the Strickland evaluation system method of assessment [10].

Hassan et al. studied the vein graft technique in 20 patients in zone II. Of these, 15 (75%) had excellent results, and the remaining five (25%) had good results. Some cases included injury of FDP only, and the others included both FDP and FDS, where the author repaired FDP and one slip of the FDS. In some cases, the vein graft was enveloped around the tendon repair, and a vein patch graft over the tendon sheath defect was used with the others. Finally, the author used the TAM method of assessment [11].

Statistically, the results of our study were a little less optimistic than those reported by most of the authors cited above. Comparison of our results with the published studies was difficult. Other investigators used different standards in their studies.

The results were affected by the technique of vein graft repair, the rehabilitation program and the method of assessment. We strictly selected our patients (adult age group, acute tendon injury of FDP and FDS tendons in zone II without associated fractures or skin loss, repair of both tendons at the same setting). Also, the rehabilitation program was standardised for both groups.

We applied the controlled passive motion protocol rehabilitation program, using rubber bands to allow for active extension and passive flexion with the protection of the dorsal blocking

Table 4 Comparison between both groups as regard Buck-Gramcko scale of assessment at 8 weeks

Variables	Excellent	Very good	Good	Fair	Poor
Group 1	0 digits (0%)	0 digits (0%)	3 digits (20%)	10 digits (66.7%)	2 digits (13.3%)
Group 2	0 digits (0%)	0 digits (0%)	3 digits (20%)	9 digits (60%)	3 digits (20%)

splint in the first 2 weeks. During the third to sixth weeks, the angles of the splint were gradually extended. This allowed for the gradual application of gentle active flexion exercises.

We used the second Buck-Gramcko scale of assessment [12]. This approach combines the ROM assessment (in the form of TAM and extension lag measurements) with the linear methods (using the pulp to distal palmar crease measurement). We believe that by employing the Buck-Gramcko II scale for assessment [12], we avoided the drawbacks of measuring the ROM (ROM) alone, which has never been tested for reliability. Also, the pulp to distal palmar crease measurement is error-prone.

Most of the authors used the TAM (total active motion) method of assessment [25], measuring the aggregated total ROM of the three finger joints. Results are divided into excellent, 100%; good, > 75%; fair, > 50%; and poor, < 50% of the normal side. However, the very good group of results is considered excellent, so expectations are higher than those in the Buck-Gramcko scale.

Five (16.6%) of the 30 operated digits developed complications. Three cases were re-operated (10%). Complications reported were as follows: repair rupture (3.3%), adhesion formation (6.6%) and joint contracture (6.6%). The rehabilitation regimen continued throughout treatment of these complications. Patients were discharged when the functional outcome was satisfactory and they had resumed normal daily activities. This complication rate is similar to those reported in the literature; an unadjusted meta-analysis reported complication rates of 14% (6% re-operation, 4% repair rupture and 4% restrictive adhesion).

In group I, with the use of a vein graft, there was only one case of late rupture (5th-week post-repair), as the patient discarded the splint and started resistive active motions without consultation. Immediate exploration and re-repair were done, and the patient was again included in the controlled active mobilisation program. The final results were less satisfactory than in other patients (good result, a Buck-Gramcko score of 11/17). However, no wound infection, no significant restrictive adhesions nor joint contractures were seen among these patients.

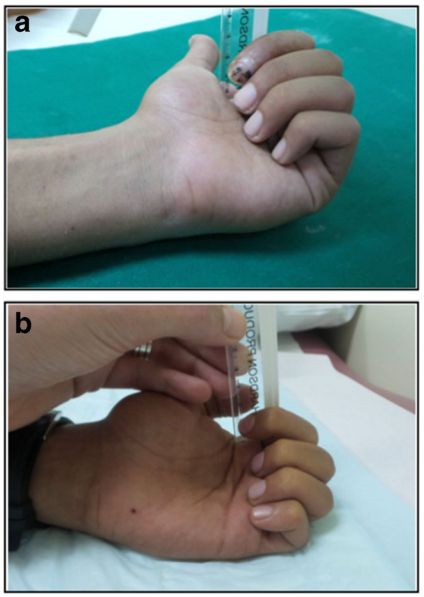

Fig. 5 **a** Photograph showing pulp to palm distance = 2 cm, score 12/17 of Buck-Gramcko scale, good result at 8 weeks. **b** Photograph showing pulp to palm distance < 1 cm, score 16/17 of Buck-Gramcko scale, excellent result at 6 months

Group II showed complications in four of 15 cases; two cases developed joint contractures. One patient developed DIP joint contracture, which improved on gradually reversed splints and active and passive ROM exercises. One patient developed PIP contracture with joint stiffness that necessitated volar capsulotomy. Two patients had adhesion, but a good ROM was achieved, and the results were less satisfactory than in other patients. In one of the two patients who had an adhesion, a tenolysis was carried out 3 to 4 months after the initial repair. No infections or repair ruptures were reported in this group.

For tendons whose repair was done using the traditional technique without paying attention to the tendon sheath in primary flexor tendon repair in zone II, there is a relatively higher rate of adhesion and joint contracture.

We believe that further studies should be done with confirmation of histological sections. The next in the study of the utility of autologous vein graft would be in tendon reconstruction with tendon grafts. Another benefit would be that, in cases of tenolysis, the vein graft would be beneficial when combined with tenolysis in bridging the sheath defect.

Table 5 Comparison between both groups as regard Buck-Gramcko scale of assessment at 6 months

Variables	Excellent	Very good	Good	Fair	Poor
Group 1	4 digits (26.7%)	5 digits (33.3%)	5 digits (33.3%)	1 digit (6.7%)	0 digits (0%)
Group 2	3 digits (20%)	4 digits (26.7%)	6 digits (40%)	2 digits (13.3%)	0 digits (0%)

Table 6 Cross table of complications in both groups

Variables	Repair rupture	Repair adhesion	Joint contracture	Wound infection
Group 1 $N = 15$	1 (3.3%)	0	0	0
Group 2 $N = 15$	0	2 (6.6%)	2 (6.6%)	0

So, the use of autologous vein graft as a replacement of tendon sheath defects has many advantages; it is inexpensive, autologous (so not carrying the risk of infection), does not sacrifice important structures and will not affect tendon healing (like other materials can); whereas, using the traditional technique in primary flexor tendon repair in zone II, ignoring the tendon sheath, has a relatively higher rate of adhesion and joint contracture.

Conclusion

Although we detected no statistically significant difference between the two groups, compared to the traditional method, using the vein patch graft as a substitution of the injured tendon sheath in primary flexor tendon repair in zone II clinically was associated with less adhesion formation, less joint contracture, improved tendon nourishment and improved function of the operated hand. We propose that the vein patch graft method can be used instead of the conventional tendon repair techniques and, ultimately, become a standard technique. We believe that the vein technique has merit, and further prospective randomised controlled trials should be performed to more fully test this approach.

Compliance with ethical standards

Conflict of interest Ahmed M. Khazbak and Ayman Abu Elmakarem Shaker declare that they have no conflict of interest.

Funding No funding was received regarding this work.

Informed consent A written informed consent for participation was obtained from all participants who had also provided informed consent for approval of publication of photographs.

Ethical approval This research has been reviewed and approved by the Ethical Committee of Scientific Research MASU 1555/2011.

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