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ORIGINAL ARTICLE

Comparison of Transverse Intraosseous Loop Technique and Pull Out Suture for Reinsertion of the Flexor Digitorum Profundus tendon. A Retrospective Study

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Abstract We compared the results of two methods for reinsertion of flexor digitorum profundus tendons retrospectively. In 35 fingers of 29 patients pull-out suture and in 13 fingers of 11 patients transverse intraosseous loop technique was performed with a mean follow-up of 8 and 6 months, respectively. Eleven and nine fingers achieved "excellent" or "good" function according to Strickland and Glogovac at 8 weeks; 20 and ten at the last control in the pull-out and transverse intraosseous loop groups, respectively. The difference at 8 weeks was statistically significant in favour of the transverse intraosseous loop group. Ten patients underwent 12 complications in the pull-out group (four superficial infections; one rerupture, one PIP and one DIP joint contracture, one adhesion, two granulomas, one nail deformity and one carpal tunnel syndrome) and four of them were reoperated (one carpal tunnel release, one teno-arthrolysis and two resections of granuloma). There was no complication and no reoperation in the transverse intraosseous loop group, the difference being statistically significant for the former. In our study the transverse intraosseous loop technique seemed to be a safe alternative with possibly better functional results compared to the pull-out suture.

Keywords Flexor tendon · Reinsertion · Pull-out suture · Transverse intraosseous loop technique

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Introduction

Flexor digitorum profundus (FDP) tendon avulsions and divisions in zone 1a with a distal stump insufficient for placing a conventional suture need reinsertion directly onto the distal phalanx. Bunnell used a metal wire, tied over a button on the nail to reattach the tendon [1]. This pull-out suture (POS) and its modifications are widely used [2]. The method is functional, but may be associated with complications: infection, rerupture, loosening of the suture wire and button, catching in clothes, nail bed damage, skin necrosis and discomfort during removal. Use of bone suture anchors or other internal fixation devices may reduce the risk of the above-mentioned complications, but the difficulties with adjusting the tension, inapplicability to children, high technical demand or high cost can still cause trouble. The simple transverse intraosseous loop technique (TILT), where the suture is passed through a transverse drill hole at the base of the distal phalanx, is designed to minimize such problems [3].

We adopted a modification of this method [4] and compared the functional results and complications with the traditional POS fixation retrospectively.

Material and Methods

Patients

This study was approved by The National Committee for Medical and Health Research Ethics (NEM) with a reference number 2010/1284. The data were collected retrospectively from the patients' records. All patients over 18 years of age operated between January 2005 and May 2010 in our department with primary or delayed primary flexor tendon repair in zone 1a were included. Replantation, revascularization, postoperative immobilization, severe DIP joint injury, thumb tendon injury and dropout from the follow-up were

exclusion criteriae. We included 40 patients: 29 in the POS and 11 in the TILT group including 35 and 13 tendon reinsertions, respectively. Patient characteristics are shown in Table 1.

Surgical Technique

The choice of technique was the surgeon's preference. Twelve surgeons carried out the POS procedures. Three surgeons changed to TILT and performed the TILT procedures of the present material. The site of repair was exposed through a standard palmar zigzag incision, extending the original wound in case of open injury. The tendon sheath was opened distally and the proximal tendon stump retrieved, if necessary through a separate proximal opening. In the POS group a 4–0 stainless steel suture (Pull out wire set, Ethicon Inc., Sommerville, NJ, USA) was placed in a modified Kessler pattern in the proximal tendon stump and threaded through the loop of the pull-out wire proximally. Canals were drilled diagonally from palmar to dorsal through the distal phalanx and the sterile matrix of the nail. The suture wires were passed through the canals and tied over a plastic button. The pull-out wire was passed proximally along the tendon sheath penetrating the skin near the PIP joint crease (Fig. 1).

The same approach was used in the TILT group. 3–0 braided composed polyethylene and polyester suture (FiberWire, Arthrex Co., Naples, FL, USA) was used for the core suture in side locking loop configuration [5]. A transverse intraosseous tunnel was drilled through the distal phalanx, halfway between the proximal nail fold and the distal interphalangeal joint. Two small stab incisions on both sides of the tunnel were created to prevent catching of soft tissues

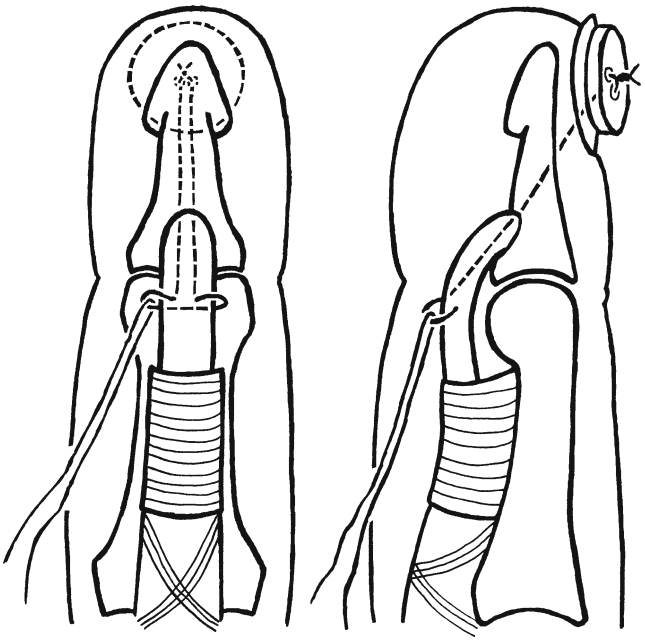

Fig. 1 Reinsertion of avulsed FDP tendon with POS, placed in the tendon as a modified Kessler suture

Table 1 Patient characteristics

	POS (N=29)	TILT (N=11)
Age: (years), mean (range)	41 (21–62)	39 (22–56)
Males	24	6
Smoking	7	4
Right hand	17	3
Dominant hand	18	3[a]
Multiple finger injuries	12	3
Finger injured	35	13
index	11	2
long	10	6
ring	9	2
little	5	3
Degree of soft tissue damage		
type 1 or 2 closed avulsion	7	2
sharp cut	7	7
moderate crush	17	3
severe crush	4	1
Associated injuries		
one neurovascular bundle	8	3
two neurovascular bundles	5	1
slight joint injury or phalanx fracture	3	1
Delay of surgery: (days), median (range)	2 (1–36)	1 (1–18)

[a] statistically significant difference between the groups (p<0.05)

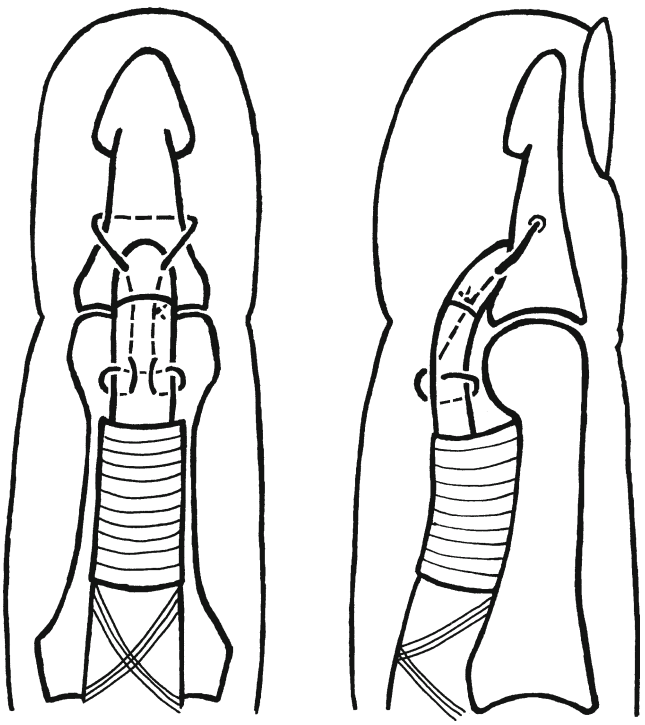

Fig. 2 Reinsertion of a zone 1a FDP laceration with TILT: Yotsumoto side locking loop core suture performed with 3–0 braided polyester and polyethylene

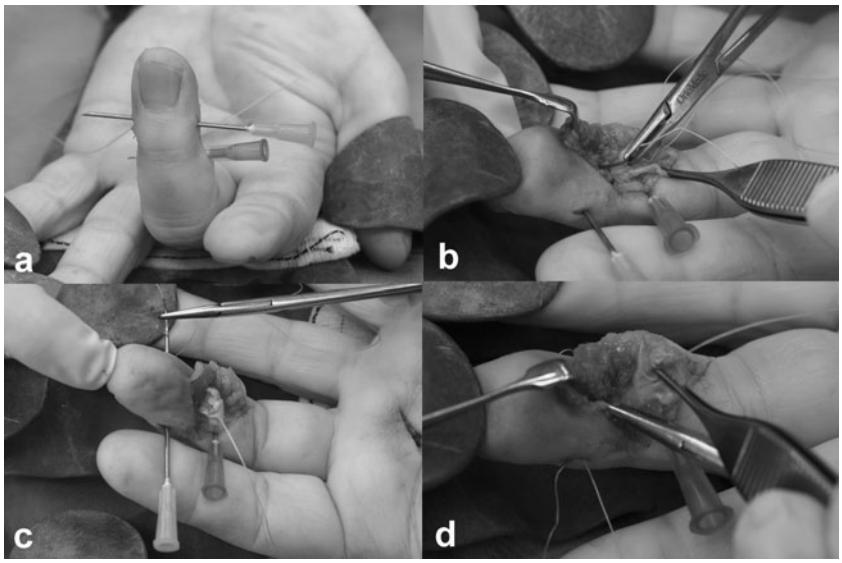

Fig. 3 Intraoperative photos of a 53-year-old man with a type 2 closed FDP tendon avulsion, operated with TILT. **a** An 18-gauge cannula was drilled through the distal phalanx. **b** The needle of the suture was passed out through a lateral stab incision, **c** inserted into the tip of the cannula. By retrieval of the cannula the suture was passed through the bone canal, and out through the stab incision on the contralateral side, then removed from the cannula (**d**) and passed from the stab incision back into the palmar wound where it was knotted at the repair site

between the suture and the bone. After inserting the suture in the proximal tendon end, the needle was passed through the distal tendon remnant (if any) and out through the lateral stab incision staying close to the bone. The needle of the suture was inserted into the tip of an 18-gauge cannula which was driven through the bone canal; retrieval of this cannula helped passing the suture through the bone and out through the stab incision on the contralateral side. Finally, the suture was removed from the cannula and passed from the stab incision back into the palmar wound close to the bone and once again through the tendon remnants. Care was taken to pass the suture deeper than the neurovascular bundle [4]. The suture was tied burying the knot at the repair site (Figs. 2 and 3).

Postoperative Care and Rehabilitation

After surgical treatment of associated injuries wound closure was carried out. All the patients were equipped with extension block splint and rubber traction attached to the nail on the injured fingers. Active extension–passive flexion exercises began on the first postoperative day. All the patients followed this rehabilitation protocol; seven in the TILT group were allowed limited active finger flexion in addition to the former. The splint was removed at 4 weeks and all the patients begun with active exercises. The pull-out wire was removed during the fifth postoperative week.

Assessment

The characteristics of the two groups were compared using the following statistical methods: independent-sample T test for the age of the patients; Mann–Whitney test for delay of surgery; Fisher's exact test for gender, smoking, side, dominance and multiple finger injuries; Chi square test for the finger injured, degree of soft tissue damage and associated injuries.

The total active range of motion (ROM) for both the PIP and DIP joints were recorded at 8 weeks and at the last follow up and compared using independent sample T-test. The function of the fingers was graded according to Strickland and Glogovac [6]. The OR for "excellent" or "good" function between the groups was gained from multiple logistic regression models, adjusted for age, gender and eventually the variables in which the two groups differed significantly. Complications and reoperations were recorded and analysed using the Fisher's exact test. A p value of 0.05 or less was considered statistically significant.

Results

The mean length of the follow-up was 8 (range 2–35) and 6 (range 2–12) months in the two groups, respectively.

Table 2 Total active range of motion of the joints, mean (SD)

Joint	POS (n=35)		TILT (n=13)	
	8 weeks	Follow up	8 weeks	Follow up
PIP	76 (21)	88(17)	90(23)[b]	96(13)
DIP	25(18)	34(18)	35(15)[b]	42(13)[b]
PIP + DIP	101(34)	123(28)	125(36)[a]	138(22)[b]

[a] statistically significant difference between the groups (p<0.05)

[b] borderline significant difference (0.05<p<0.1)

Table 3 Functional results graded according to Strickland and Glogovac

Grade	PIP + DIP ROM	POS (N=35)		TILT (N=13)	
	(degrees)	8 weeks	Follow up	8 weeks	Follow up
Excellent or good	≥125	11	20	9[a]	10
Excellent	≥150	3	7	3	6
Good	125–149	8	13	6	4
Fair	90–124	12	12	1	3
Poor	<90	12	3	3	0

[a] statistically significant difference between the groups (p<0.05)

There were significantly more dominant hand injuries in the POS group; however the two groups did not differ significantly with regard to any other patient characteristic (Table 1).

All the ROM measures were slightly better in the TILT group; however the difference was significant only for the combined PIP and DIP ROM at 8 weeks (Table 2). "Excellent" or "good" functional grading was found in 11/35 and 9/13 fingers at 8 weeks, and in 20/35 and 10/13 at the last control of the POS and TILT groups, respectively (Table 3, Fig. 4). The multiple logistic regression models showed better functional result using TILT both at 8 weeks and at the last follow up, the former difference being significant (p=0.03; OR=12; 95 %CI 1.2; 110 and p=0.18; OR=3.5; 95 %CI 0.55; 22, respectively).

Ten patients in the POS group experienced 12 complications: four superficial infections were cured with per oral antibiotics; one of them developing rupture of the repair. One significant PIP and one DIP joint contracture, one adhesion, two granulomas, one nail deformity and one postoperative carpal tunnel syndrome were recorded. Four patients were reoperated: one carpal tunnel release, one teno-arthrolysis and two resections of granulomas. There was no complication and no reoperation in the TILT group, the difference being statistically significant for the former (p=0.02 and p=0.56, respectively).

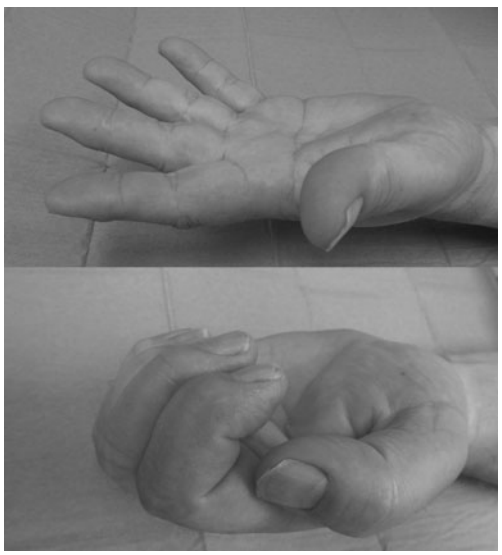

Fig. 4 The same patient 12 month after the reinsertion: one of the best functional results, graded as excellent

Discussion

In our study we found superior functional results with the transverse intraosseous loop technique compared to pull-out suture. We are confident that the TILT is safe; it had fewer complications and avoided the problems of button tie-over and skin irritation due to the pull-out wire, it interfered neither with the nerves nor the germinative matrix and the nail plate.

With both methods the site of reattachment is close to the natural insertion point of the FDP tendon. Adjusting the tension is easy for both by tightening of the suture. Both techniques replicate the physiological direction of pull on the bone, which is not the case in the alternative transosseus tunnel method where the suture is passed transversely through the tuberosity of the distal phalanx [7]. The more distal pull with the latter method could make the patients more prone to developing flexion contracture of the DIP joint.

The use of double bone anchors in combination with FiberWire suture was shown to be biomechanically superior to POS in a human cadaver study, but good bone stock was a prerequisite [8]. This method may not be suitable for the elderly or others with osteoporosis since the anchors could loosen from the distal phalanx. However, the TILT is still applicable because the load is distributed throughout the entire width of the phalanx including the hard lateral cortex. In addition fixation with bone anchors is technically more demanding and definitively more expensive.

The weakness of our study is the retrospective design, the lack of randomization and the small sample size in the TILT group. In spite of the limited sample sizes we were able to show significant functional superiority of the TILT at 8 weeks; however the difference was smaller at the last follow up. Maybe we could find more robust differences in single joint ROM comparisons, and not only in the combined PIP and DIP ROM at 8 weeks, if the TILT sample size was larger.

Our material could be biased by the different number of surgeons involved in the two procedures. POS was the well-

established procedure, mastered by all surgeons of the department. The novel TILT technique was kept to a limited number of hands to increase standardization. Every operation in both groups was carried out with sufficient competence following basic hand surgical principles. The introduction of a new and unfamiliar technique could also result in poorer results. However, none of the procedures were technically demanding. It is therefore unlikely that the variations between the groups were due to different surgeons or attention on other surgical details than the reattachment technique.

Our regression model results were corrected for hand dominance as the factor in which the two groups differed significantly. The rehabilitation was left out of consideration as a possible source of difference; the program for all patients was basically the same, every patient underwent a thorough rehabilitation program with tight follow up by specialized hand therapists. The seven TILT cases, who were allowed to flex the actual finger actively, only did that after warming up according to the same protocol as followed by the others. On the contrary, we experienced that several of those who were not allowed active flexion, tried to bend their finger anyway, also including the POS group. We did not consider the rehabilitation program to be an important factor for the outcome of this study, neither for the functional results nor the complications.

Tripathi reported a mean of 59° of DIP and 91° of PIP ROM with TILT [3]. All his patients had closed tendon laceration and underwent an early active mobilization program. The mean follow up of his 12 cases was 11 (range 3–16) months. He observed 2 fixed DIP flexion contractures. We were unable to achieve such a good functional result; maybe due to including open tendon lacerations with associated injuries. However, we did not observe significant contractures. Our results are comparable with the retrospective results of Moiemen and Elliot on 20 tendon repairs in zone 1a [9]: 14 dissections near the insertion and six type 2 closed FDP tendon avulsions according to Leddy and Packer's classification [10]. Reinsertion of the tendon was carried out with a modified polypropylene Kessler core suture passing either through the bone and nail complex and tied over an external button or through the above mentioned transverse tunnel in the tuberosity of the distal phalanx [7]. All fingers were mobilized early postoperatively in a controlled active motion regimen. The follow up was a minimum of 12 weeks. They found excellent or good results according to Strickland and Glogovac [6] in 14/20 fingers (70 %). This is slightly better than our results with totally 30/48 (63 %) excellent or good ratings; however with TILT alone we achieved excellent or good results in 10/13 (77 %).

Moiemen and Elliot proposed measuring the range of motion only in the DIP joint for the assessment of zone 1 injuries [9]. They concluded that this method is more sensitive than those including the PIP joint. The latter usually regains normal function after a more distal injury and in spite of a stiff DIP joint the finger can be graded as "good". Still, we chose to employ the Strickland-Glogovac [6] system, because soft tissue irritation from the pull-out wire may hinder PIP joint motion as well, as our measurements showed. The pull-out wire can move back and forth under finger exercises, causing inflammation or infection in more severe cases, discomfort and pain. In addition the patients can be more protective because of the button and less eager with finger motion. On the contrary, there is no soft tissue irritation with TILT during finger movements.

The complication rates of POS are relatively high; varying from 35 [11] to 65 % [12] compared to 38 % in our study. The high incidence of inflammatory changes, granulomas and infections may be related to soft tissue irritation. The carpal tunnel syndrome in our material is not a direct complication to the tendon surgery, but it is a known complication to any hand operations with excessive oedema. As it occurred early postoperatively without any pathology in the contralateral hand, it might be a consequence of soft tissue irritation and swelling; that is why we considered it as a complication. In our opinion the higher complication rate with POS is due to the dissimilarity in technique and not to the rehabilitation protocol.

Our results suggest that safer alternative methods, such as TILT may be preferable to POS for zone 1a tendon repairs.

Declaration of no conflicting interests All named authors hereby declare that they have no conflicts of interest to disclose. They did not receive any grant or other financial support for this work. They also state that they have full control of all primary data and that they agree to allow the journal to review their data if requested.

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