Modified Brunelli pull-out technique in flexor tendon repair for zone II: a study on 58 cases

Alexandru Valentin Georgescu · Ileana R. Matei ·
Irina M. Capota · Filip Ardelean · Octavian D. Olariu

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Abstract

Background The reconstruction of the continuity of flexor tendons disruptions in zone II still remains one of the most challenging problems in hand surgery. The ideal repair has to provide sufficient strength and the possibility of early mobilization in the attempt to obtain a functional range of motion. One of the methods which appears to respond to these requests is the pull-out technique described by Brunelli, which moves the tension from the level of the tendon disruption to the finger pulp over the tendon insertion.

Methods After using this method, but by doing some modifications of the original technique, our aim was to conduct a retrospective study looking at gap formation, suture strength, rupture rate, efficiency of the two-strand suture repair and of the early active mobilization against resistance in obtaining a good range of flexion rate. We reviewed a series of 71 flexor digitorum profundus disruptions in zone II, in 58 patients admitted in our service between 2000 and 2008, and treated with this method.

Results We achieved a complete range of flexion in 41 fingers (57.7%) and a flexion deficit of 5–10° in eight fingers (11.3%) and of 10–20° in 22 fingers (31%). We had no ruptures, major strength deficit, or bowstringing.

Conclusions Our study demonstrates that, by moving the tension from the level of disruption to the finger pulp, the rehabilitation program can begin very early post surgery. We had 0% ruptures.

Keywords Flexor tendon · Zone II · Pull-out technique · Immediate mobilization

Introduction

Reconstructing the continuity of finger flexor tendons in zone II still remains one of the most challenging problems in hand surgery [16, 31]. Considerations such as: complex local anatomy, demanding technique, demanding skilled and attentive postoperative rehabilitation, and compliance of the patient all play a part in outcome. Although the flexor tendon lesions represent less than 1% of all hand injuries [17], they can affect to an important degree the function of the hand, with negative impact for both the patient and society [27].

The ideal repair of these lesions has to provide sufficient strength and the possibility of early mobilization, in the attempt to obtain a functional range of motion. The two-strand modified Kessler suture combined with a circumferential running suture represents one of the most used techniques for zone II [14, 22, 37]. In the attempt to increase the strength of this type of suture, numerous multi-strand techniques were described [1, 6, 13, 18, 28, 29, 32, 34, 38, 39]. To avoid the possible bulkiness of the tendon by using these techniques, Brunelli and Monini [4, 5] described a technique which theoretically shifts the point of maximum stress from the tendon site to the tendon insertion site. The original technique of Brunelli and Monini consists in creating a slipknot using a two needles 3–0 or 4–0 nylon monofilament suture. The needle enters transversally through the proximal stump at 1 cm proximal to the cut edge and as close as possible to the dorsal aspect of the tendon. Then, the needles reenter symmetrically the tendon 0.5 cm distally and exit through the cut edge. The needles enter the distal stump and run longitudinally to exit through the tendon insertion

A. V. Georgescu (✉) · I. R. Matei · I. M. Capota · F. Ardelean ·
O. D. Olariu
Clinic for Plastic Surgery and Reconstructive Microsurgery,
Hospital for Rehabilitation,
Iuliu Hatieganu University of Medicine and Pharmacy,
Cluj-Napoca, Romania
e-mail: geordv@hotmail.com

and finger pulp, where the suture is tied on a button. The stumps are maintained aligned by applying a 8–0 or 9–0 epitendinous running suture. The authors state that this technique provides a tighter contact of the tendons' stumps during the muscle contraction. Also, the traction force is transmitted to the distal phalanx level and the tendon is free to glide naturally.

Our experience in using this technique and the modifications we created in 71 fingers with flexor digitorum profundus (FDP) disruptions operated on by the same senior surgeon is presented.

Materials and Methods

Between 2000 and 2008, the senior author treated 58 patients with disruption of the FDP in zone II, by using the pull-out technique described by Brunelli and Monini in 1982 [4]. There were 71 FDP disruptions: one tendon in 48 cases, two tendons in six cases, three tendons in two patients, four tendons in one patient, one case with lesion of the flexor pollicis longus. In 61 fingers, the flexor digitorum superficialis (FDS) was also involved, and in 34 fingers associated digital nerves disruption was recorded. Skin defects were also recorded in seven cases.

The average age of the patients was 33.5 years (range, 6–71 years) and 37 out of 58 were males. The injury involved the dominant hand in 43 patients. The most common etiology of injury was by cutting and only in few cases by crushing or other complex mechanisms. The interval between injury occurrence and date of surgery was 1 to 3 days (mean, 1.64 days).

Technique

The details of the technique are presented in Figs. 1 and 2.

The procedure is generally done under regional intravenous anesthesia with the tourniquet placed in the distal third of the arm and with minimal sedation, excepting the children and anxious patients, in which general anesthesia is preferred. After debridement, the wound is enlarged, both proximally and distally through zigzag or mid-axial incisions, the distal one being over the non-functional border of the finger. The uninjured annular pulleys are preserved or partially incised, but the cruciate pulleys are opened and the proximal stump of the FDS, if also disrupted by the trauma, is excised (Fig. 2a). The tenorrhaphy is done with a 3–0 monofilament non-absorbable single needle suture (first modification of the original technique). The second modification in the Brunelli

Fig. 1 Diagram of the modified Brunelli pull-out technique. **a** The suture is started from the finger pulp. **b, c, d** The completion of the sliplink. **e** The suture passes through the distal stump. **f** The suture is

tied over on the finger pulp, and a 5–0 absorbable circumferential running suture completes the procedure

Fig. 2 Modified Brunelli pull-out method-technical details. **a** The uninjured annular pulleys are preserved, but the cruciate pulleys are opened (A2, A4= annular pulleys; the A2 was partial opened) **b** The suture is started from the finger pulp and then is passed through the proximal stump in a “U” manner at 1–1.5 cm. **c** The suture is tied over. **d** The circumferential running suture. **e** The active mobilization against resistance is started after 48 h

and Monini technique is represented by the distal approach of the suture insertion through the finger pulp, instead of beginning the suture at the proximal tendons' stump (Fig. 1a). The completion of the slipknot is similar to the original technique (Figs. 1b–d and 2b). After passing through the distal stump (Fig. 1e), the suture exits and is tied over on the finger pulp (Figs. 1f and 2c). The third modification is represented by using a 5–0 absorbable circumferential running suture (Figs. 1f and 2d). In case of associated lesions of the digital nerves, they are repaired in standard fashion. For the cases presenting also skin defects, they are covered by using local or regional flaps. Before closing the skin, the gap formation is controlled by passive and active mobilization of the finger. The active mobilization is possible only when the patient is under regional intravenous anesthesia, and when the time for surgery is no more than 1 h. The gap formation during mobilization is carefully assessed by using magnifying loupes. A splint is then applied, with the wrist and MP joints flexed for 15–20° (fourth technique modification) and the PIP and DIP joints extended. Both the passive and active controlled mobilization is started the next day, under the supervision of the physiotherapist. After 48 h, the active mobilization against resistance is added (fifth technique modification; Fig. 2e). The resistance is created by maintaining the PIP and DIP joints

extended using a 1.1 mm diameter circular rubber band, anchored on the dorsal aspect of the wrists' bandage. The patient is encouraged to progressively flex the fingers, reaching the complete active flexion against resistance at 8–10 days post-surgery. The skin sutures are released in the 14th postoperative day and the tie-over suture in the 21st day. After 3 weeks, this splint is released and a dynamic splint for the operated finger(s) only is added. This one is maintained until the end of the first month, and then the patient is encouraged to immobilize the finger(s) in extension during the night for 2 months. The patients were carefully examined every week to ensure that the mobilization program was correctly performed. The active range of motion of the fingers was assessed according with Strickland's criteria (the sum of the active range of motion of the MP, PIP, and DIP joints of the injured fingers compared with the contra-lateral healthy finger and expressed as a percentage) [30]. The pinch strength was measured using the pinch gauge.

Results

The average follow-up was 7.8 months (range, 3–24 months). In only seven patients the follow-up was of 5 months, and at that moment, the range of motion was

already normal. All patients continued to have the same social life and were able to work in the same place. No problem on the finger pulp related to the tie-over suture was recorded.

We achieved a complete range of flexion in 57.7% of fingers (41 out of 71) and a flexion deficit of 5–10° in 11.3% (eight out of 71) and of 10–20° in 31% (22 out of 71) of fingers. No tendon ruptures or major alterations in flexor strength were noted. To assess the results, we use the scoring system proposed by Strickland [30]. According with this system, our results can be judged as excellent in all the cases (regain of 75–100% of normal active movement; Figs. 3 and 4). According with the assessment system proposed by Lister [21], our results can be judged as excellent in only 39 cases (regain of flexion to within 1 cm of the distal palmar crease and an extension deficit less than 15°; Fig. 4) and good in 19 cases (regain of flexion to within less than 3 cm of the distal palmar crease; Fig. 3).

For the cases with exceptional results (according to Strickland criteria), we obtained 85–95% from the pinch strength of the contra-lateral finger (considering also the variations induced by the dominance of hand). For the good result cases, the pinch strength was 50–75% compared with the contra-lateral one.

In all the cases in which were also performed flaps, the rehabilitation regimen was the same as for the cases without skin defects, and no complications or flap losses were recorded.

Discussion

Zone II has still the reputation as one in which it is difficult to obtain very good results [16]. Three main factors contribute to obtaining of good results: skilled operative technique well adapted to the complexity of the local anatomy, skilled and attentive postoperative rehabilitation, and compliance of the patient. The goals of a tendon repair are the obtaining of a strong, but not too bulky suture, and

by causing minimal tendon trauma and intra-tendinous disruption of the architecture and blood supply [16].

Many surgical techniques have been used in the attempt to reduce gap formation to increase repair strength and to allow early postoperative mobilization. The well-known two-strand modified Kessler suture completed with a circumferential continuous suture is probably still the most common technique for zone II [14, 22, 37]. In the attempt to increase the strength of the repair, various multi-strand techniques were used [1, 6, 13, 18, 28, 29, 32–34, 38, 39], but with the disadvantage of a possible increase of the bulk of the tendon [16]. The results after these various used methods is contradictory: Momose et al. [23] consider the double Kessler, double Tsuge cruciate, and Becker sutures stronger than modified Kessler and Tsuge repairs, and Trail et al. [36] advocate the modified Kessler repair with circumferential suture to require the greatest load to produce gapping.

Despite the numerous papers advocating the advantages of multi-strand repairs, starting with 2,000 we used, with some modifications, the method published by Brunelli and Monini in 1982 [4], and again in 1992 [5], which avoids any tension between tendon stumps, by moving it through the stitch to the distal phalanx. This technique has only two strands passing into the tendon and any knot on its surface. The suture is realized with a 3–0 non-absorbable stitch pooled-out and tied-over on the finger pulp. In the original technique, the repair is completed with an 8–0 absorbable or non-absorbable circumferential running suture. The wrist is immobilized in 60° of flexion for 20 days; the passive and active mobilization can start immediately. The fact that this two-strand suture is not so strong as a multi-strand suture is compensated by the absence of any tension between tendon stumps, by moving it through the stitch to the distal phalanx. Each muscular contracture produces a tightening of the intratendinous stitch that will transmit the traction to the distal phalanx [4, 5]. This fact, together with the added slight tension to the repair site, as stated by Thang [32], and the peripheral running suture [8, 32],

Fig. 3 Final result 1 year after surgery: regain of flexion to within less than 3 cm of the distal palmar crease

Fig. 4 FDP disruption of the second digit 2 years postoperative result. **a** Finger aspect. **b, c** The degree of functional rehabilitation without flexion/extension deficit

minimize the risk of gap formation. Moreover, both the slight tension and the running suture provide additional strength to the repair [8, 32]. Unlike the original Brunelli technique, in which the running suture is done with 8/0 stitch, we use 5/0 stitch in the attempt to increase the strength.

Nowadays, it is accepted that one of the more significant mechanisms of tendon healing is the intrinsic repair [16]. So, from this point of view, it is clear that a two-strand technique is more advantageous than a multi-strand technique.

Brunelli and Monini use stitches with two long needles, which allow them to start the suture by passing both needles through the proximal stump of the tendon and then through the distal stump for exiting on the finger pulp [4, 5]. We start the suture from distal to proximal, and to avoid the pinching of the surrounding tissues, we exit from the tendon and enter back on the midway between the insertion and the stump of the tendon.

One of the disadvantages of other methods is the presence of one or two knots on the tendon surface, what generates a more or less bulkiness at the suture site and which, together with the posttraumatic and postoperative edema, can negatively interact with the tendon gliding [16, 32]. The absence of any knot on the tendon surface in Brunelli technique avoids or minimize the bulkiness and so, allows a very good remodeling of the tendon and a future better gliding.

Regarding the pulleys, some authors consider that the preservation of the A2 and A4 is essential [16, 26], but some others [29, 32, 35] advocate that partial incision of A2 and complete excision of A4 do not affect the functional outcome. On the contrary, that allows tendon gliding while avoiding clinically significant bowstringing [32]. We respect the A2 and A4, but we partially incise them to free the tendon from restriction by the pulleys, or catching on their rim, as stated by Tang [32], and we did not document any significant bowstringing.

The importance of FDS is well known in the functionality of the fingers: (1) better preservation of the blood supply of FDP through the vincular system [16, 19]; (2) much grip strength; (3) strongest flexion power; (4) balances to grip when handling objects of uneven shape; (5) together with the intrinsic muscles, balances individual finger motion; (6) better bed for the FDP. Moreover, a possible complication if the FDS is not repaired is the proximal interphalangeal swan-neck deformity [10]. However, in the attempt to avoid the adhesion, the likelihood of the tendons sticking under the A2 pulleys and, ultimately, the limitation of finger flexion, we do not repair the FDS, but we respect the distal stump to preserve the vincular system. Despite of this approach, we did not observe significant negative influence to the functional outcome.

We did not document in our series any rupture after primary repair. The general rupture rate after primary repair is considered to be between 4–10% of the fingers [20, 28, 31]. Talking only about primary flexor tendons in zone II and repaired with the Kessler and circumferential suture, most series report a rupture rate of between 3–9% [2, 3, 7, 9–12, 15]. In only one series of 95 children, O'Connell et al. [24] report a rupture rate of 0%. As stated by Powell and Trail [25], the tension in an uninjured flexor tendon during passive and active mobilization is between 0.2 to 27 N without resistance and between 2 to 48 N against resistance; so, it seems logical to increase the strength of a tendon suture by using multi-strand repairs [6]. This increase of strength is very important because it allows the application of a more aggressive exercise regimen and so, better tendon gliding and finger flexion [31]. Moving the tension from the lesion site to the tendon insertion site, the modified Brunelli technique does not need such strength, only a good alignment of the stumps, in the attempt not to be too bulky and to facilitate the tendon gliding. In these conditions, the

circumferential running suture is enough for the alignment and also for avoiding the gap formation. Moreover, the 0% rupture rate in our series could also be explained by the absence of bulkiness and by the partial incision of the A2 and/or A4 pulleys.

In conclusion, moving the tension from the repair site to the finger pulp allows the very early beginning of the active mobilization against resistance. This contributes to a very good modeling of the tendon, minimal adhesion formation, and avoids the joints stiffness and the extension deficit of the interphalangeal joints.

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