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Flexor digitorum profundus with or without flexor digitorum superficialis tendon repair in acute Zone 2B injuries

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Abstract

A total of 53 patients with complete cuts of two flexor tendons in Zone 2B treated over a 9-year period was reviewed. Twenty-three patients (28 fingers) had only flexor digitorum profundus repair, while 30 patients (36 fingers) had both flexor digitorum profundus and flexor digitorum superficialis repairs, with a mean follow-up of 21 months (range 12–84). The decision to repair the flexor digitorum superficialis was made according to intraoperative judgement of ease of repair and gliding of the flexor digitorum profundus tendon. Two groups of patients showed no significant differences in total range of active or passive digital motion and power grip percentage to the contralateral hand. However, the values of power grip were statistically superior in the patients with both tendons repaired. The patients after flexor digitorum profundus-only repairs showed significantly greater but still mild flexion contracture (mean 20°) of the operated digits. The Tang gradings were the same with 89% good and excellent rates in both groups. The conclusion is that although repair of both flexor digitorum profundus and flexor digitorum superficialis tendons is slightly more preferable based on increased grip strength, the repair of the flexor digitorum superficialis together with flexor digitorum profundus is not mandatory. Whether or not to repair flexor digitorum superficialis is an intraoperative decision based on the ease of gliding of the repaired tendon(s).

Level of evidence: III

Keywords

Primary flexor tendon repair, Zone 2B injuries, flexor digitorum superficialis, flexor digitorum profundus, range of digital motion, power grip of the hand, outcomes

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Introduction

The area between the distal edge of the A2 pulley and the insertion of the flexor digitorum superficialis (FDS) tendon in the finger is called Zone 2B (Tang and Shi, 1992). In repairing flexor tendon cut in Zone 2B, there is a question whether the FDS has to be repaired and whether its repair produces better outcomes than either resecting or not repairing the FDS tendon. Currently, many surgeons agree that in Zone 2C (the area covered by the A2 pulley) the cut FDS should not be repaired because this area is the narrowest based on basic and clinical studies (Pan et al., 2019, 2020; Tang, 1994; Tang et al., 2003, 2007; Xu and Tang, 2003; Zhao et al., 2002). Zone 2B, however, does not have any rigid pulley, and theoretically there is a greater freedom in deciding the repair or excision of the FDS tendon.

There are scarce reports evaluating Zone 2B injuries or comparing isolated flexor digitorum profundus (FDP) versus both FDS and FDP repair in this subzone. Most of the reports have discussed the different subzones of Zone 2 flexor tendon injuries or have focused on areas under A2 or A4 pulleys (Elliot et al., 2016; Moriya et al., 2016a, 2016b, 2017, 2019; Tang, 1994, 2018). The author of this study conducted a retrospective analysis of all patients who sustained

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combined FDS and FDP tendon injuries in Zone 2B in a 9-year period. A comparative study was performed to compare outcomes between those after repairing only the FDP or repairing both FDS and FDP tendons. Outcome measures were total range of active motion (TAM), functional grades, grip strength and flexion contracture of the proximal interphalangeal (PIP) joint.

Patients and methods

Patients

One hundred sixty-seven patients with acute complete laceration of both FDS and FDP tendons at Zone 2 were operated at our centre in a 9-year period from January 2009 to December 2017. Among these patients, 104 patients (145 fingers) had injuries in Zone 2B.

Inclusion criteria for this study were the patients with acute sharp injuries to the flexor tendons, which were repaired within a week after injury; complete FDP tendon laceration with complete or partial FDS tendon laceration, which were treated with end-to-end tendon repair of either both FDS and FDP or FDP alone; and patients older than 16 years. Exclusion criteria included patients who did not complete follow-up of 12 months (12 patients); patients younger than 16 years of age (nine patients); delayed presentation to the surgeon for over a week after injury (none); and associated extensive skin, vascular or osseous injuries of the involved digit(s) or hand (30 patients). Consequently, 53 patients (64 fingers) were eligible for inclusion in this study and completed their follow-up until the final personal interview.

The fifty-three patients had two types of repair in their cut flexor tendons: repair of only the FDP tendon (23 patients, 28 fingers) (17 male and six female with a mean age of 28 years (SD 7); range 18–40) and repair of both FDP and FDS tendon (30 patients, 36 fingers) (19 male and 11 female with a mean age of 30 years (SD 7); range 18–46) (Table 1). The patient charts and records were reviewed to compare outcomes after the two types of tendon repairs. Human ethical committee approval and informed consents from all patients were obtained for this study.

Anaesthesia

From 2009 to 2015, regional anaesthesia either via axillary block or local intravenous anaesthesia was the main anaesthetic protocol for the patients with flexor tendon repairs. General anaesthesia was used for non-cooperative patients sometimes. After induction of anaesthesia, an arm tourniquet (adjusted to 100 mmHG above patient's systolic blood pressure) was applied. This was used for 17 patients (25 fingers) in this series. From 2015 to 2017, wide awake local anaesthesia no tourniquet (WALANT) (Lalonde and Martin, 2013) has been the routine anaesthetic technique employed in our centre and was used for 30 patients (33 fingers) except in six patients (six fingers) because of noncompliance. In such cases, the doses adopted by Lalonde have been used in the form of 1% lidocaine with 1:100,000 epinephrine and 8.4% bicarbonate (mixed in 10:1 ratio) (Lalonde and Wong, 2013). Approximately 10–15 ml were injected and distributed along the volar aspect of the distal palmar crease and over the proximal and middle phalanges. In WALANT patients, surgery was

Table 1. Demographic and preoperative data of both groups.

Demographics	FDP only repair (Patients: 23; digits: 28)	FDP and FDS repair (Patients: 30; digits: 36)	*p*-value
Age (years)	28 (SD 7, 18–40)	30 (SD 7, 18–46)	0.238
Male/female patients	17/6	19/11	0.413
Right/left	8/15	18/12	0.069
Dominance (R/L)	22/1	28/2	0.717
Affected digit (single/multiple)	18/5	26/4	0.478
2, 3, 4, 5 (digits)	2, 2, 11, 13	9, 7, 6,14	0.052
WALANT, Regional, General	16, 12, 0	17, 12, 7	**0.035**
Time to surgery (hours)	7 (3–168)	8 (3–96)	0.712
Follow-up (months)	21 (SD 14, 12–84)	20.5 (SD 13, 12–84)	1

SD: standard deviation. Range is presented in parenthesis or after SD.
WALANT: wide awake local anaesthesia no tourniquet.

postponed for 25 minutes to allow for the maximal vasoconstrictive effect of epinephrine to take effect. After prepping and draping, the site of injury was extended with a modified Bruner's incision. Exploration and surgery were performed under loupe magnification (×2.5).

Surgical techniques

The incision was extended proximally for 1 cm to retrieve the proximal tendon stump. In case the proximal stump was not retrievable, a transverse distal palmar crease incision was performed to capture the tendon stump proximal to the A1 pulley. After retrieval of the proximal stumps of both injured tendons, the FDP tendon was repaired using three groups of Tsuge-like repair (totally six strands) using 4-0 nonabsorbable monofilament polypropylene sutures (Prolene; Ethicon, Somerville, NJ, USA). One lock made with the suture was inserted in the tendon at each end of the three groups of sutures, and the size of the lock was 1–2 mm according to the width of the tendon (Figure 1). A continuous simple running peripheral suture was added with 6-0 Prolene. This was followed by evaluation of the ease of tendon gliding underneath the A2 pulley. If the repaired FDP tendon exhibited triggering or difficult gliding during finger passive or active flexion, the FDS tendon was resected (at its insertion). If gliding of the repaired FDP tendon was smooth, the FDS was repaired with a modified Kessler stitch using 4-0 Prolene.

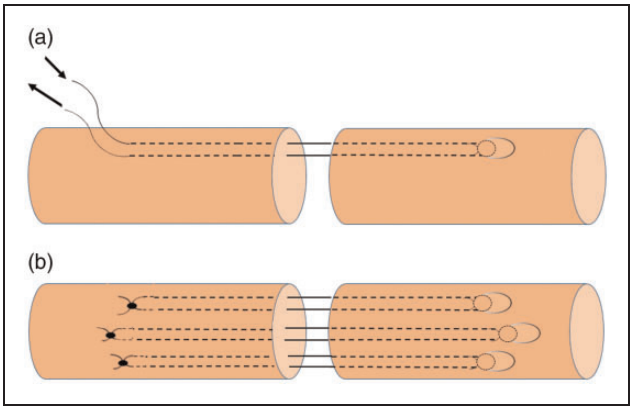

Figure 1. Three groups of Tsuge-like suture using nonlooped Prolene 4-0 suture; (a) Placement of the first two-strand Tsuge-like suture. One end is a locking suture anchor to the tendon with two circled locks at different orientations and depths, and the other end is a grasping suture anchor with a knot outside the tendon surface. (b) Placement of the whole construct six-strand Tsuge-like suture technique; finishing the repair with epitendinous running 6-0 Prolene suture.

The patient using WALANT was instructed to actively flex his involved digit(s) for the whole arc of flexion and extension to assess the presence of triggering or difficulty in tendon gliding, which might necessitate further venting. In all cases, the A2 pulley was vented or partially resected with preservation of a minimum of 50% of its proximal vertical extension. After the tendon repair was completed, the skin incision was closed (Figure 2). All patients reviewed for this study were operated by the author of the study. My expertise level for surgical repair of the tendon is Level 3 (Tang and Giddins, 2016).

Postoperative care and rehabilitation

Dorsal splinting and position. A dorsal wrist splint extending from the tips of the fingers to below the elbow and maintaining the wrist in neutral position was applied for the first postsurgical week. The metacarpophalangeal (MCP) joints were positioned in 50° of flexion and the interphalangeal (IP) joints in full extension. In addition to the dorsal splinting, a rubber band was attached to the tip(s) of the operated digit(s) with a 2-0 silk suture via a stitch through the nail. The rubber band's proximal end was fixed at the wrist crease via a pin attached to the elastic bandage supporting the dorsal splint. Its tension was adjusted to allow maximal digital flexion and passive maximal digital extension within the splint.

Motion exercise in week 1. During the first postoperative week, the patients were instructed to actively flex their operated digit(s) as tolerated and encouraging painless range of extension starting from day 2. This was routinely performed once daily in one 5-minute session.

Motion exercise and anti-oedema treatment from week 2 to 4. All patients were seen by the author around the end of week 1 or week 2. During this visit, the dorsal splint was temporarily removed and the rubber band detached. The patients were subjected to passive gentle full range of motion for 5 minutes, followed by asking them to actively flex and extend their digits to full range of digital motion for another 5 minutes under supervision of the author. In case of inability to perform full range of digital motion due to pain or swelling, the sequential passive and active range of motion exercises were performed to the maximum extent allowable.

Special emphasis was given to anti-oedema measures to progressively increase the range of motion in the sequential later visits. The anti-oedema measures (as instructed by the author) composed of: strict forearm and hand elevation, gentle passive finger motion exercise, anti-oedema drugs in trice daily doses before meals (Ambezim tablets; Global

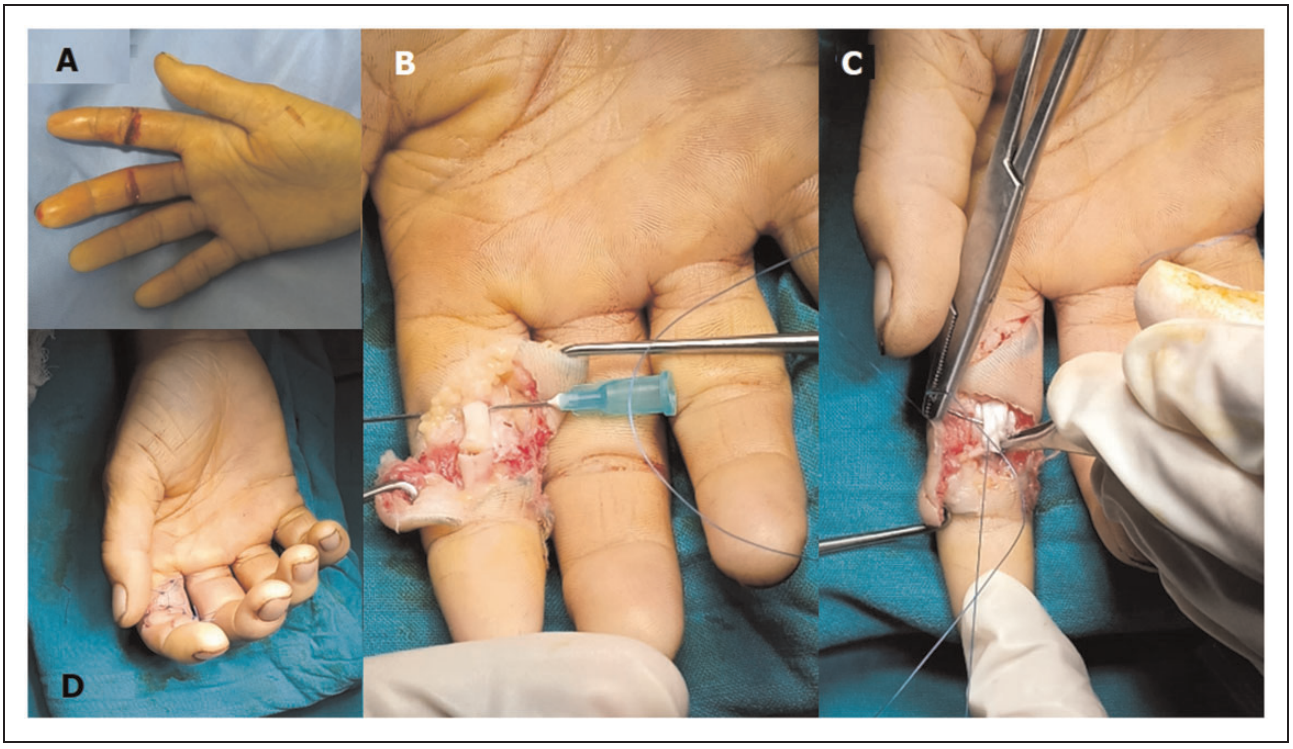

Figure 2. (a) Preoperative photograph of a laceration in Zone 2 in the index finger and superficial wound at Zone 2 in the middle finger in a 30-year-old woman with injured FDP and FDS at Zone 2B. (b) Intraoperative photograph confirming preoperative diagnosis and showing approximation of both proximal and distal stumps of the FDP tendon. (c) Intraoperative photograph showing the initial Tsuge-like 4-0 Prolene stitch. (d) The final resting position of the index finger intraoperatively after skin closure showing normal flexion cascade.

Napi Pharmaceuticals, Cairo, Egypt) and topical recombinant Hirudin gel trice daily (Thombexx gel, MINAPHARM Pharmaceuticals, Cairo, Egypt). Patients with marked oedema were seen every other day by the author until subsidence of the oedema. There were no therapists' instructions to the patients or to the author regarding this matter.

Differential excursions of both FDS and FDP tendons were encouraged by passive and active flexion of the PIP and distal interphalangeal (DIP) joints, flat fist and hook fist exercises. Home-based exercises were taught to the patients during their visit in clinic. This home-based training was composed of exercises performed in my presence in the first visit in week 2, in addition to holding cylinders with gradually decreased diameters each week (see below). The exercises were repeated twice daily with each session lasting for only 5 minutes.

The author taught the patients to routinely and regularly hold different cylinders with an incrementally decreased diameter during each rehabilitation session starting from day 8. The patients were instructed to grasp cylindrically shaped objects in a cupping posture to smooth and strengthen flexion of the operated digits. For example, in the second week the patients were asked to start grasping a bottle of water in a wider based cup without carrying the bottle to reduce the work of flexion. Then they used progressively decreasing diameter cylindrical objects (cups, cans, etc.) until the end of week 6 when they were capable of achieving comfortably full range of flexion as compared with the contralateral hand (Figure 3).

Motion exercise without splinting in week 4 and 5. Sequential weekly visits to the author were scheduled for follow-up until the end of the week 4. The splint was discarded at this time, which left the operated finger(s) protected with only a rubber band (attached from fingertip to the distal wrist crease by adhesive plaster tape) (Figure 4).

At weeks 5 and 6 after surgery, the anticipated full range of motion (compared with the contralateral sound digit(s)) was promoted through active digital flexion exercises, which were enforced and extended to almost 15 minutes daily in three daily sessions (5 minutes each session) with the rubber band detached proximally. After the end of the exercise session, the rubber band was reattached proximally for protection of the finger from active use or full extension. At the end of week 6, the rubber bands were removed

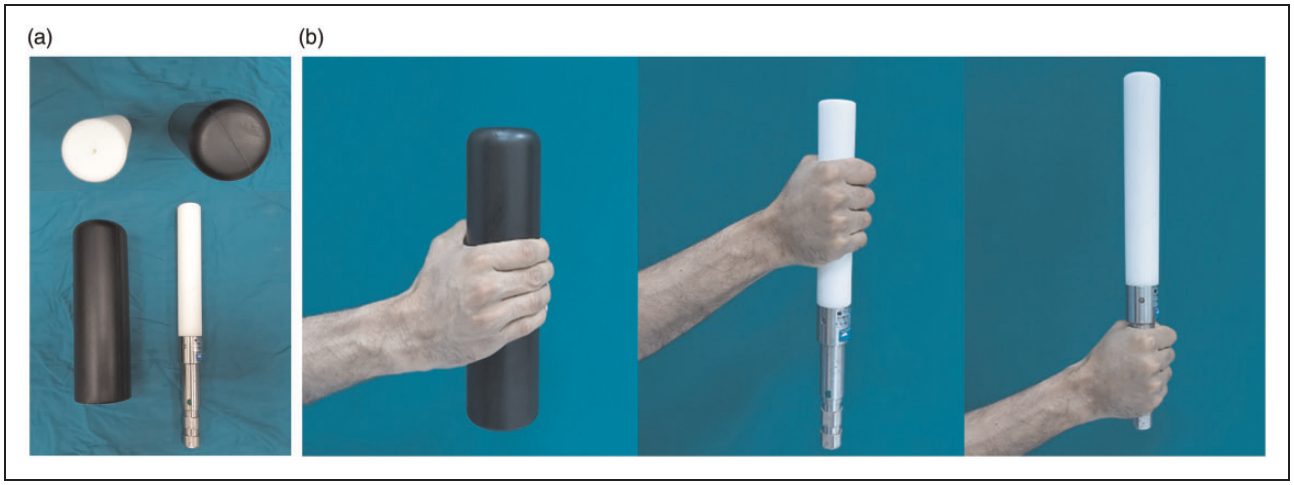

Figure 3. (a) Photographs of different diameter cylindrical posts that are routinely used for smoothing and strengthening of flexion of the operated digits (could be replaced by similar diameter home objects, e.g. water bottle, cans, cups). (b) Photographs of a patient using the previously shown posts for flexion (normally, these posts are routinely supported on a table during the early rehabilitation period to decrease the work of flexion and thus to unplanned extra loading of flexor tendons).

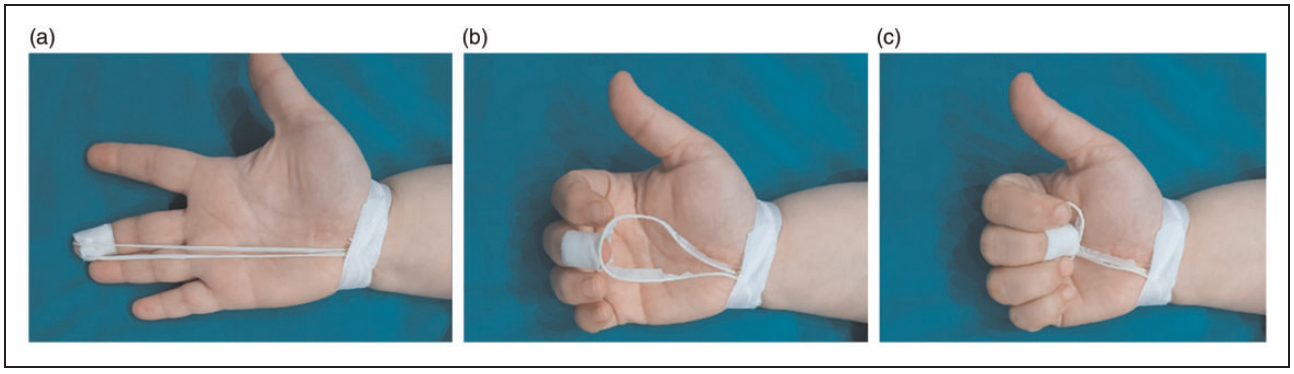

Figure 4. Sequential extension and flexion of the middle finger in a 40-year-old woman on week 5 with the only protection provided by rubber band attached at the wrist crease with adhesive plaster. (a) Finger extension, (b) finger flexion, (c) full flexion of the finger.

allowing initiation of full active flexion/extension exercises without any protection, stressing on differential motion initiated by each isolated tendon (Supplemental Videos 1–7, available online). At week 12 the patients started resistive digital motion exercises and normal use.

Functional evaluation

TAM of the operated digit(s) was calculated as the sum of range of motion of the MCP, PIP and DIP joints. Its percentage to the contralateral uninjured digit(s) were also calculated. The total passive range of motion (TPM) of the digit(s) were measured by the author using a hand-held goniometer at the final follow-up. The functional outcome was assessed using the Tang grading system based on the sum of the active range of motion of the PIP and DIP joints, excluding the MCP joint (Tang, 2007, 2013). Grip strength and its percentage to the contralateral normal hand were also evaluated using Jamar hand held dynamometer (Sammons Preston, Bolingbrook, IL, USA). Moreover, any complication or flexion deformity was recorded.

Statistical analysis

Data were reported as median, interquartile range (IQR), or means and standard deviation (SD) and range. The Mann–Whitney test was used for analysing non-parametric quantitative data between the two groups. The chi-square test or Fisher's exact test was used for qualitative data between two groups of patients. Independent samples *t* test for parametric

quantitative data compared the two groups. The Kruskal–Wallis test was used for non-parametric quantitative data if patients were divided to more than two groups for analysis, which was followed by the Mann–Whitney test between each two groups. The one-way analysis of variance test was used for parametric quantitative data between multiple groups followed by post hoc analysis between each two groups. Significance level was set at $P < 0.05$.

Results

Twenty-three patients (28 fingers) had FDP only repair, while 30 patients (36 fingers) had both FDP and FDS repairs (Table 1). In both groups of patients, the mean follow-up was 21 months (range 12–84) (Table 1).

Finger motion, flexion deformity and functional grades

The patients of both groups showed no statistically significant differences regarding TAM, TAM percentage to the contralateral non-injured digits, TPM, grip percentage to the non-injured side and duration of surgery. On the final follow-up evaluation, the grip strength was statistically greater in patients with FDP and FDS repairs ($p = 0.014$) (Table 2). The patients with FDP only repair showed significantly greater flexion deformity at the operated digits PIP joint (mean 20° after FDP only repair, while 5° after FDP and FDS repair) ($p = 0.008$).

The final evaluation using Tang criteria showed statistically significant difference in recovery between the two groups, with the digits with two tendons repaired showing slightly better in the grading ($p = 0.036$) (Table 2). The good and excellent scores for the patients with FDP only repair was 89%, and 89% with FDS and FDP repair, but the statistical difference in grading was due to a large number of fingers (20 out of 36) with FDS and FDP repair had 'good' outcomes, while fewer were graded 'excellent' (12 out of 36). In contrast, 17 out of 26 fingers with FDP only repair graded 'excellent' (Table 2). When the good and excellent incidence was analysed with the chi-square test, no significant difference was found.

Complications

Rupture of the repaired FDP tendon occurred in one finger in each group within the first postoperative week. The surgery for repairing the ruptured FDP

Table 2. Postoperative outcomes of the patients in two groups.

Assessment	FDP only repair (28 fingers)	FDP and FDS repairs (36 fingers)	*P*-value
TAM (°)	241(SD 28, 150–270)	236 (SD 22, 180–270)	0.441
TPM (°)	265 (SD 12, 210–270)	266.7 (SD 8, 240–270)	0.507
TAM%	89 (SD 11, 56–100)	88 (SD 9, 67–100)	0.457
Power grip (kg)[a]	30 (28–34)	35 (29–40)	**0.014**
Power grip%	84 (SD 14, 56–100)	85 (SD 13, 60–100)	0.869
Flexion deformity (°)	20 (1–20)	5 (0–10)	**0.008**
Surgical time (minutes)[a]	40 (30–75)	50 (40–75)	0.244
Tang grading[b]			**0.036**
Excellent	17	12	
Good	8	20	
Fair	2	3	
Poor	0	0	
Failure	1	1	
Complications[c]	4	7	0.743
Severe contracture	2	1	0.608
Tendon rupture	1	1	
Severe adhesions	0	3	

[a]Data are presented as median and interquartile range. Unlabelled data are mean (range) or number of digits.
[b]Tang grading was according to the percentage of the sum of active range of motion of the proximal and distal interphalangeal joints of the operated finger to that of the contralateral corresponding finger.
[c]Only the cases which needed another surgery to correct were accounted as complications.
FDP: flexor digitorum profundus; FDS: flexor digitorum superficialis; TAM: total active motion; TPM: total passive motion; SD: standard deviation; TAM%: percentage of TAM of contralateral corresponding finger; Power grip%: percentage of the power grip of the other hand.

tendon (without FDS repair) was performed with the same 6-strand repair method with peripheral sutures for the two fingers on the day of FDP rupture. The final follow-up score of both cases was rated (failure), though after re-doing the repair, one (with FDP only repair) was graded poor and another good at final follow-up.

Three fingers were operated for correcting flexion contractures and another three fingers for adhesions. Among three fingers with flexion contracture, two fingers had FDP only repair and one finger had FDP and FDS repairs (Table 2).

Three patients (each with one finger involved) had tourniquet palsy (one with FDP only repair and two with FDP and FDS repair). These patients completely recovered by 1 week, 2 weeks and 1 month postoperatively. The three fingers have achieved a Tang score of good at the final follow-up.

Outcomes of single versus multiple finger injuries

Among patients with FDP only repair, those sustaining single digit injury showed significantly better TAM percentage to the contralateral sound digit ($p = 0.044$), grip strength ($p = 0.01$) and grip percentage to the contralateral side ($p = 0.005$) than patients with multiple digits affection (Table 3).

Regarding Tang scoring, patients having single digit involvement showed statistically significant better functional evaluation than those with multiple digits involved ($p = 0.001$). In addition, they exhibited significantly less flexion deformity at the PIP joint ($p = 0.003$) and less operative time ($p < 0.001$). Conversely, among patients with FDP and FDS repair, patients with multiple digit involvement achieved statistically significant better TPM than those with single digit affection ($p = 0.033$). These patients with single digit affection demonstrated significantly better power grip than those with multiple digit affection ($p = 0.014$).

Outcomes of WALANT versus other types of anaesthesia

The type of anaesthesia applied to the operated patients was correlated to the final outcome parameters. In WALANT, grip strength was statistically higher in comparison with other types of anaesthesia in FDP and FDS repair patients ($p = 0.014$). The duration of surgery was significantly shorter in WALANT with FDP and FDS repair ($p = 0.013$).

Moreover, in WALANT-operated patients with FDP only repair, the number of excellent digits was 11 out of 16, but in the FDS and FDP repair patients this was six out of 17, indicating possible slightly better outcomes with surgery performed using WALANT. The number of fingers in each group was small, so the difference could not be analysed with sufficient statistical power. In addition, WALANT was used in recent years and the author's surgical expertise was improved over earlier years, thus the analysis can be biased.

Discussion

In this study, the author did not find any significant differences between the two groups regarding TAM, TAM percentage to contralateral non-injured digit(s) or TPM. The findings imply that the repair of the FDS is not mandatory in Zone 2B, but if the repair is possible, it may yield better outcomes, especially for grip strength but not the final grades of function. The fingers with close-to-normal (excellent) grading after repairing the FDP only repair were more frequent than those after repairing two tendons. No PIP joint hyperextension in the patients lacking FDS repair was noted. Therefore, prevention of PIP joint hyperextension should not be a concern in deciding whether the FDS should be repaired. The judgement leading to FDS repair should be based on whether repair of the FDS would impinge on gliding of the FDP tendon or if repair of the FDS tendon would be difficult.

Fewer patients developed flexion deformity at the PIP joint when both tendons were repaired compared with those with the flexion deformity. The flexion deformity occurred in a number of fingers with FDP only repair, but the contracture was generally mild, most of these fingers were still rated 'excellent' (see Table 2 and supplementary Table S1, available online). A possible explanation is an unconscious difference in the author's rehabilitation protocol between the two groups.

Currently, combined passive and active motion regime is the mainstay rehabilitation after Zone 2 flexor tendon repair (Lalonde, 2019; Pan et al., 2019, 2020; Tang, 2007, 2013). The author adopted an early supervised active rehabilitation protocol and had excellent and good cases in 89% in patients of both groups, which is higher than most of the reported series, which range from 70% to 90% excellent and good rates (Elliot, 2002; Moriya et al., 2017; Tang, 2005, 2013), but similar to those of the more recent reports (Giesen et al., 2018; Pan et al., 2019, 2020; Zhou et al., 2017). This could be related to meticulous personal individual-based follow-up, persistent (though short period) daily home-based training and frequent follow-up visits (every other day in cases of postoperative oedema). This series of patients was treated by a single surgeon, and

Table 3. Analysis of impact of the repair of a single or multiple digit injuries on the final outcomes.

	FDP only repair			FDP and FDS repair		
Assessment	Single digit	Multiple digits	*p*-value	Single digit	Multiple digits	*p*-value
TAM (°)	248 (SD 29, 150–270)	227 (SD 21, 190–250)	0.052	240 (SD 22, 200–270)	231 (SD 23, 180–260)	0.242
TPM (°)	264 (SD 15, 210–270)	266 (SD 7, 250–270)	0.756	264 (SD 10, 240–270)	269 (SD 2.4, 260–270)	**0.033**
TAM %	92 (SD 11, 56–100)	84 (SD 9, 70–92)	**0.044**	89 (SD 8, 74–100)	86 (SD 9, 67–96)	0.244
Power grip (kg)[a]	32 (29–36)	28 (25–30)	**0.010**	38 (35–42)	30 (28–38)	**0.014**
Power grip %	89 (SD 11, 63–100)	75 (SD 14, 56–88)	**0.005**	89 (SD 12, 63–100)	81 (SD 14, 60–100)	0.065
Flexion deformity (°)[a]	7.5 (0–20)	20 (20–41)	**0.003**	0 (0–10)	5 (0–10)	0.568
Surgical time (minutes)[a]	35 (30–40)	80 (75–86)	<**0.001**	45 (40–60)	75 (40–105)	0.057
Tang grading[b]			**0.001**			0.324
Excellent	14	3		6	2	
Good	3	5		16	8	
Fair	0	2		3	0	
Poor	0	0		0	0	
Failure	1	0		1	0	
Digits with complications	2	2	0.601	7	1	0.408

TAM: total active motion; TPM: total passive motion; TAM%: percentage of TAM of contralateral corresponding finger; Power grip%: percentage of the power grip of the other hand.
[a]Data are median and interquartile range.
[b]Tang grading was according to the percentage of the sum of range of active motion of the proximal and distal interphalangeal joints of the operated finger to that of the contralateral non-injured corresponding finger.
Other data are presented as mean with standard deviation (SD) followed by range, or number of digits.

follow-up visits were more frequently arranged for those with severe oedema. Our unit did not have a therapist. Consequently, the author instructed motion exercise of all these patients. The patients in this series are all younger than 47 years old (as the cases above that age were excluded from the study due to either loss to follow-up or being associated with other soft tissue or bony injuries), and all injuries were sharp. These two factors contributed to the favourable results. If there were more complex injuries or the patients were older, prolonged rehabilitation would be required and outcomes would not be as good as in this report.

Strong repairs of the lacerated tendons allowed early active flexion exercise from the second postoperative day with gradually increasing range of active motion under protection in the first 4 weeks. Also of value were the gradual weaning from protection (with rubber band, without splinting) in weeks 5 and 6, complete disposal of protective measures after the end of week 6 and raising the threshold of exercises to a resistive type on week 7 through week 12. In this rehabilitation protocol, the rubber band is used for protection of the operated finger and prevents use of the finger, not for passive finger flexion. The patients performed combined passive and active motion with the rubber band detached and the hand was out of the splint. Perhaps the rubber band contributed to PIP joint flexion contracture in some patients, as the rubber band has a well-known problem of causing finger joint contracture, and the use of a rubber band for passive finger flexion is an abandoned practice nowadays (Karalezli, 2019; Lalonde, 2019; Rigó et al., 2017; Tang, 2007, 2018; Wu and Tang, 2014). In the future, use of the rubber band will be discontinued to see if PIP joint contracture occurs less frequently.

In addition, compared with the currently popular standard passive-active motion regime currently, the daily duration of motion (for 10–15 min) is remarkably shorter. The standard motion regime requires several hours of active exercise. The reason why the present series still has outcomes comparable with those recently reported with hours of daily exercise (Giesen et al., 2018; Pan et al., 2019, 2020) remains elusive. It may be that in the present series, patients discarded the splint earlier (at the end of week 4), and patients actually often moved over a short range from week 5 because there was no splint (only with rubber band for protection), though the exercise protocol ordered was only 15 minutes daily. The results from the current series may suggest that splinting can be discarded earlier (at the end of week 4) than currently done (at the end of week 5 or 6) (Moriya et al., 2019; Pan and Chen, 2019; Pan et al., 2019, 2020). Because a 6-strand repair is very strong, it is reasonable that the splinting has a shorter duration, perhaps for 4 weeks. The patients may be able to have short durations of active motion before the end of week 4, but more frequent exercises for hours after week 4. These suggestions are assumptions, which need to be proven in future case series.

The author used a 6-strand repair technique as it provides sufficient strength (Bigorre et al., 2018; Gibson et al., 2017; Giesen et al., 2018; Khanna et al., 2009; Reissner et al., 2018; Tang, 2007; Wu and Tang, 2014). For FDS repair, the author used a modified Kessler technique that was found biomechanically sufficient in these situations (Sebastin et al., 2013). Placing the suture knots outside the tendon surface as a core suture in this series appears to have no disadvantages, which is better than placing the knots between tendon stumps (Chang et al., 2018; Chen et al., 2018; Pan et al., 2019, 2020). In this series, there were two repair ruptures in two fingers, but immediate re-repair was done; and despite outcomes of the re-repaired tendons of poor in one and good in another, the Tang functional grading for both cases was considered to be failures in this report.

The advantages of the WALANT technique are well appreciated in active intraoperative digital flexion allowing accurate assessment of adequacy of repair, tendon gapping or triggering. The application of WALANT expanding (Lalonde and Martin, 2013; Xing and Mao, 2018, 2019). In the author's unit, WALANT is now used for flexor tendon repairs more frequently. It is not the main purpose of this report to compare WALANT versus other anaesthesia for flexor tendon repair; there were no differences in functional grading, but the operative time was significantly shorter with WALANT.

The conclusion from our patients treated over a 9-year period is that although repair of both FDP and FDS tendons is slightly more preferable based on increased grip strength, the repair of the FDS together with FDP is not mandatory. Whether or not to repair FDS is an intraoperative decision based on the ease of gliding of the repaired tendon(s).

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up, the author was the only one who performed clinical follow-up and personal interviews. I understand that the functional grades reported here are better than those in many previous reports despite the remarkably shorter duration of daily exercises and early discarding of the splint protection. However, I have all electronic records of patients' follow-up. I will be happy to respond to any interested colleagues to share such data with them. I will also welcome any colleagues to examine our charts or records in my institute.

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Supplemental material Supplemental material for this article is available online.

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