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# The result of the repair of an index finger pulp amputation with a concomitant flexor digitorum profundus tendon tear in Zone 1, using a combination of a cross-finger flap and pull-out tendon suture: a case report

Bernard Piotuch[A] ✉, Filip Fliciński[B]

Pomeranian Medical University in Szczecin, Department of General and Hand Surgery, Unii Lubelskiej 1, 71-252 Szczecin, Poland

[A] ORCID: 0000-0001-9337-8077; [B] ORCID: 0000-0002-8898-677X

✉ bernard.piotuch@gmail.com

**ABSTRACT**

Flexor tendon injuries classified as Kleinert Zone 1 are challenging to repair, particularly in cases involving complex injuries with soft tissue defects. This report presents a case of a patient who sustained an amputation of the pulp of the index finger with a concomitant flexor digitorum profundus tendon tear in Zone 1. The patient underwent immediate surgery under brachial block anesthesia. The complex injury was treated using a combination of a cross-finger flap for the pulp defect and a pull-out flexor tendon suture. The postoperative course was uneventful, and the patient recovered within 3 months. A final clinical assessment conducted 4 months after the accident showed normal hand function, allowing the patient to return to his original job. In addition to the treatment approach used, the article discusses other suitable treatment options for this type of injury.

**Keywords**: finger pulp amputation; flexor tendon repair; cross-finger flap; finger reconstruction; outcome measures.

## INTRODUCTION

Flexor tendon injuries in Zone 1 (according to the Kleinert classification; Fig. 1) are difficult to repair. In 1940, Bunnell described a surgical technique that allows for reliable repair in cases of distal stump loss of the flexor digitorum profundus (FDP) tendon [1]. Over the years, as surgical experience with this technique has accumulated, several complications have been identified. Nail deformity, infection, osteomyelitis of the distal phalanx, and flexion deformities of the distal interphalangeal (DIP) joint are well-recognized complications that sometimes necessitate amputation as a definitive treatment [2]. Despite these challenges, the technique has been used for nearly a century in various modifications, including different suture materials, strand numbers, strand directions, and anchoring methods. However, no single technique has proven to be distinctly superior in reducing complication rates or improving outcomes [3].

In clinical practice, surgeons frequently encounter complex cases where a "simple" tendon injury is complicated by fractures, soft tissue loss, or both, requiring versatile approaches. Typically, the loss of soft tissue coverage at the fingertip is addressed using one of several well-described techniques, each with its own advantages and drawbacks. Commonly used methods include homodigital V-Y advancement flaps, cross-finger flaps from adjacent fingers, thenar flaps, or random flaps harvested from the groin or trunk [4]. The multitude of available techniques can create confusion, and the literature offers limited "practical" guidance on managing complex injuries in this zone. Moreover, some techniques require a higher level of surgical expertise without necessarily yielding superior results.

This report presents an interesting treatment option for a complex injury involving an FDP tendon laceration in Zone 1, combined with a distal phalanx fracture and an amputation of the index finger pulp due to a crush injury. To our knowledge, no published evidence describes this particular combined treatment. We hope this case contributes meaningfully to the existing literature by providing practical insight into managing such injuries.

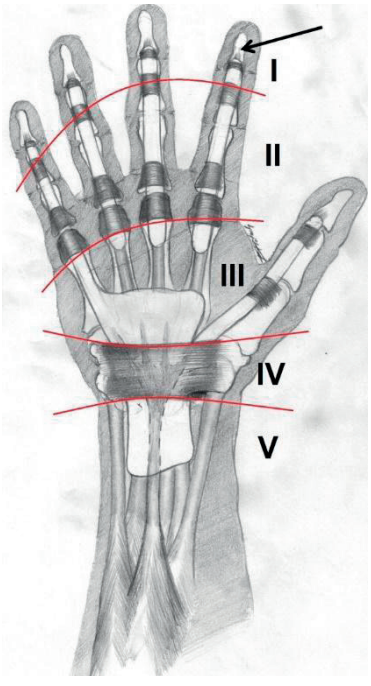



**FIGURE 1.** Zones of the flexor tendons in the hand according to Kleinert classification

## CASE REPORT

A 27-year-old manual worker sustained a crush injury to the distal aspect of the index finger on his left (non-dominant) hand. He was referred directly to our specialized center. The injury resulted in extensive soft tissue loss on the palmar aspect of the index finger (Fig. 1, 2). The distal stump of the FDP tendon was avulsed from its bony attachment at the base of the distal phalanx, and a metaphyseal fracture of the distal phalanx was also noted. Due to the extent of the tissue loss, which included bone abrasion and tendon detachment, flap coverage was required. Because the injury was too extensive for coverage with a homodigital flap, a decision was made – after discussing treatment options with the patient – to use a pull-out suture repair for the FDP tendon in combination with a cross-finger flap from the adjacent finger.

The wound was irrigated and surgically debrided. The distal phalanx fracture was anatomically reduced (Fig. 3). Two 1.2 mm K-wires were used to create 2 antegrade bony tunnels, beginning proximal to the fracture line and exiting dorsally through the nail just distal to the lunula to preserve the germinal matrix. A double-needled 3/0 suture was used for a 2-strand Kessler core repair; the needles were straightened to pass through the bony tunnels. The suture was knotted over a resilient plastic button, cut from a surgical drain (Fig. 4a). The FDP tendon attachment was reinforced with a 5/0 running resorbable suture. The palmar soft tissue defect was reconstructed using a cross-finger flap from the adjacent middle finger (Fig. 4b), with additional sutures securing the skin of the index finger to the skin of the middle finger (Fig. 4a). The donor site on the dorsal aspect of the middle finger was reconstructed with a full-thickness skin graft harvested from the palmar wrist and secured with a sutured dressing. The entire procedure was performed under brachial plexus block anesthesia.

The surgery and postoperative course were uneventful. Postoperatively, the hand was immobilized in a plaster splint with the wrist in 20° flexion, while the fingers remained free to move within the splint's boundaries but were restricted from full extension at the metacarpophalangeal joints. The rehabilitation protocol included controlled, assisted simultaneous flexion of all fingers 4–6 times per session, 6 times a day. At 3 weeks postoperatively, the flap was divided, and the fingers were separated. Full active flexion was allowed after 4 weeks. The core suture was removed at 6 weeks, and the splint was discontinued.

The patient did not undergo any formal rehabilitation program. Unrestricted gripping was permitted after 3 months, and he returned to work at that time. At the final follow-up, the patient had regained full grip strength and full finger range of motion, with a slight residual contracture at the DIP joint and compensatory hyperextension at the proximal interphalangeal (PIP) joint (Fig. 5). The patient reported satisfactory sensibility in the flap, was pleased with both the appearance and function of the finger, and experienced only minimal paresthesia and cold intolerance. The final assessment was conducted 4 months postoperatively, and the results are summarized in Table 1.

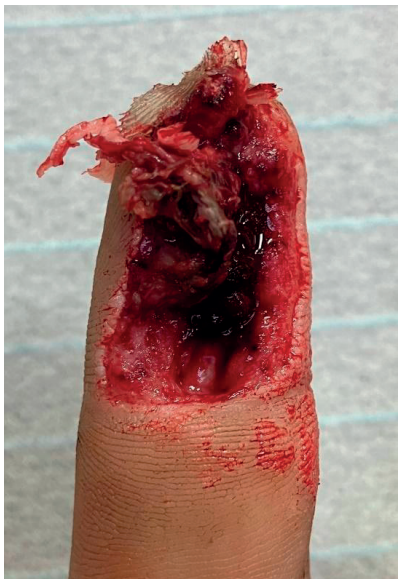
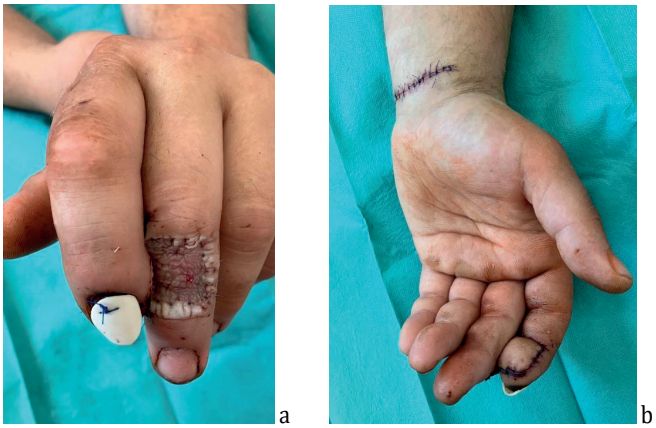


**FIGURE 2.** Initial injury to the tip of the index finger

**FIGURE 3.** Intraoperative view showing anatomical reduction of the fractured distal phalanx



a b

**FIGURE 4.** View of the hand 1-week after surgery: (a) pull-out suture in nail of the index finger and healed skin graft on the middle finger; (b) index finger pulp defect covered by a cross-finger flap


a


b

**FIGURE 5.** Final appearance of the hand at 4 months: (a) full finger flexion; (b) full finger extension

**TABLE 1. Results of the objective measures at 1.5 year after surgery**

| Variable | Injured hand (nondominant) | Contralateral hand (dominant) |
|---|---|---|
| DASH score | 2 | |
| Grip strength | 44 kG | 40 kG |
| Filament test | purple | green |
| 2-point discrimination | 8 mm | 3 mm |
| DIP range of motion | 60° | 76° |
| PIP range of motion | 112° | 93° |
| PIP + DIP range of motion | 172° | 169° |

DASH – disabilities of the arm, shoulder and hand; DIP – distal interphalangeal; PIP – proximal interphalangeal

## DISCUSSION

In this paper, we present a complex injury of the distal part of a finger requiring combined repair of both the flexor tendon attachment and the coverage of the palmar aspect of the finger, complicated by a distal phalanx fracture. The literature still lacks information on how to address such combined injuries, despite injuries to the distal parts of fingers being among the most common. Therefore, it seems prudent to present possible surgical approaches for practitioners, supported by evidence of favorable results.

Decision-making in such injuries must consider multiple factors. The reality of busy hand surgery wards demands techniques that are predictable in terms of operative time and have a low threshold for failure or revision. The simplicity of the procedure, reliability, and donor site morbidity concerning vocational activities had to be considered when deciding on the 2 crucial elements of repair – tendon reconstruction and defect coverage.

Although modern suture anchors seem to reduce the risk of infection and statistically improve the time to return to work, they require a robust bone stock for insertion. Therefore, a fracture of the distal phalanx precluded the use of an anchor suture, favoring a simple pull-out repair of the flexor tendon. This technique offers statistically comparable outcomes in terms of sensibility, active range of motion, flexion contracture, grip strength, and risk of failure [5]. In the presented case, the average grip strength measured at the final follow-up was 10% greater in the injured, non-dominant hand than in the uninjured dominant hand. Nevertheless, the patient scored 2 points in item 11 of the disabilities of the arm, shoulder and hand (DASH) score, as he believed he had unconsciously adapted to relying less on the injured finger during the healing process and was occasionally bothered by paresthesia upon heavy loading of the fingertip area. Nonetheless, this is still a remarkable outcome, as both deep flexor repair and soft tissue loss reconstruction would typically impair grip strength [6].

The presence of a PIP shaft fracture further complicated decision-making. However, after reduction, we deemed the fracture stable, particularly since the entire fingernail was preserved. The risk of nonunion, although extremely low, is not impossible. If there had been any doubt, we would likely have opted for K-wire or mini-screw stabilization [7]. Since K-wire fixation often requires DIP joint transfixation, leading to a higher incidence of postoperative stiffness and movement limitation, screw fixation would likely have been our preferred choice [8].

A more significant challenge was the reconstruction of the soft tissue defect. Given that the entire palmar aspect of the index finger was missing, we excluded commonly described options such as Atasoy or Kutler flaps, as these allow only limited advancement and are typically used to reconstruct small amputated tips of distal phalanges [9]. Among the options that allow for greater tissue excursion and broader coverage, the choices included the thenar flap, Venkataswami flap (a homodigital neurovascular long V-Y advancement flap), cross-finger flap, and random flaps from the trunk [10]. Our primary objectives were to ensure flap survival, provide adequate coverage of the entire palmar aspect of the distal phalanx, allow early mobilization, and restore tactile sensitivity.

Random flaps from the trunk (chest or groin areas) offer the greatest ability to cover large defects. Although technically simple to perform, even under local anesthesia, we excluded this option because the required hand positioning would have significantly hindered the patient's daily life, prevented early motion protocols, and complicated monitoring of the tendon reconstruction's integrity and function. Furthermore, such flaps do not provide tissue that matches the lost pulp, potentially affecting finger function later in life. Additionally, we typically reserve this type of flap for multi-digital injuries or cases requiring coverage of larger areas than a single finger segment [11].

All of the aforementioned flaps, except for the Venkataswami flap, do not restore sensation, as they lack viable nerve supply. First described in 1980, the Venkataswami flap has several advantages – it utilizes tissue from the affected finger and has significant potential for covering segmental defects [12]. However, it is technically more demanding and, while generally reliable, carries the risk of vascular injury to the pedicle, which could result in the loss of an even larger area of coverage [13]. Despite its benefits, the Venkataswami flap has limited coverage potential and typically requires positioning the finger in flexion, increasing the risk of flexion contracture of the DIP joint – a common issue after FDP reconstruction in Zone 1 [14]. The Venkataswami flap has the potential to restore sensation to the pulp area as it

carries a proper digital nerve supply, with reported 2-point discrimination values ranging 3–7 mm. Some studies even report near-normal sensation in patients treated with this flap [14, 15]. However, results with other local flaps have also been satisfactory. In the presented case, the patient retained sensation at the level of the purple filament in the Semmes–Weinstein filament test and had an 8 mm 2-point discrimination ability, which aligns with reported outcomes [15]. The patient did not report a lack of sensation at any point during postoperative follow-ups. The only concerns he expressed were mild cold intolerance with prolonged exposure to low temperatures and paresthesia upon forceful fingertip loading. These issues were reflected minimally in the DASH score, with items 11, 26, and 27 scoring 2 points due to "paresthesia" sensations. None of the reconstructive options can fully prevent cold intolerance, but in this case, it was not functionally significant.

Another simple option is the thenar flap, first described in 1957. It is a well-established reconstructive method that provides resilient, color-matched tissue with adequate bulk [16, 17]. It also offers limited sensation. Reported complications include partial flap necrosis, cold intolerance, and flexion contracture of the recipient finger. Although historically feared for potential donor site issues, it has proven to be an excellent solution in the right context. Technically simple, the main drawback is that it requires the involved finger to be positioned in fixed flexion to reach the thenar area. This position must be maintained for at least 2 weeks, which precludes early active rehabilitation and significantly increases the risk of residual contracture. As a result, this technique was excluded in our case. For larger defects, the donor site may not be closed primarily, occasionally requiring additional coverage with a free full-thickness skin graft. Sensory outcomes are similar to those in our case, with static 2-point discrimination ranging 4–10 mm [17, 18, 19].

Ultimately, we opted for the well-established cross-finger flap. First introduced in 1950, this technique is one of the most versatile and extensively studied, with numerous modifications to refine its original design [20, 21, 22]. In this case, where the entire volar coverage of the distal phalanx was lost, the cross-finger flap provided adequate coverage. Al-Qattan's modification allows for defects spanning 2 phalanges to be treated simultaneously [22]. This flap can also be used sequentially across multiple fingers in a "walking" manner. Importantly, it permitted passive and active motion of the affected fingers during the healing process.

Although Koch et al. reported mild donor finger stiffness in 68% of patients, along with pain and cold intolerance in a third of cases, our experience and that of others suggest that meticulous surgical technique, full-thickness skin grafting instead of split-thickness grafting, early mobilization, and timely flap division can mitigate these issues [6]. Donor finger stiffness tends to occur when the skin graft extends over a joint and is more pronounced in older patients [23, 24]. Premature flap division risks necrosis, but this can be anticipated by compressing the base of the flap at the time of division – severe discoloration indicates inadequate perfusion and the need for delayed separation. In this case, the flap was divided after 2.5 weeks, which we have found to be sufficient for viability, as confirmed by numerous published series [24]. Additionally, our case supports the feasibility of early motion protocols following cross-finger flap reconstruction, as the patient was encouraged to mobilize his fingers from the first postoperative day.

Cosmetically, our patient was satisfied, but it is worth noting that in non-Caucasian patients, donor site skin grafts may develop hyper- or hypopigmentation. Additionally, dorsal finger hair may create an unsightly "hairy" pulp. Reported time to return to work after cross-finger flap reconstruction ranges of 4–6 weeks, depending on postoperative rehabilitation protocols [24]. For pull-out button vs. anchor FDP reconstructions, average return times were 12 and 10 weeks, respectively. Our patient resumed vocational duties 3 months postoperatively, a median value. However, we believe that return-to-work times are more influenced by insurance policies than by treatment quality.

## CONCLUSIONS

The abundance of techniques described for both FDP tendon repair in Kleinert Zone 1 and the reconstruction of soft tissue defects on fingers can be disorienting. Proper planning of reconstruction, based on evidence, is crucial for achieving favorable outcomes in less obvious and infrequently encountered combinations of soft tissue and bony injuries. Planning should consider not only the surgical procedure but also the need for postoperative rehabilitation. Over the years, there has been a clear shift toward early motion protocols in rehabilitation to enhance outcomes. Our case strongly supports the feasibility of implementing early motion protocols when reconstruction options are carefully selected.

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