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Hand

A Novel Prolene Suture Pull-out Technique Combined with Anchor Technique for the Treatment of Tendinous Mallet Finger

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Background: Mallet finger deformity is a prevalent disability that causes discomfort and inconvenience to the patients. Despite the existence of various surgical approaches, surgical management remains a controversial subject.

Methods: We retrospectively analyzed the clinical data of 26 patients with isolated tendinous mallet fingers who were admitted between January 2021 and June 2022. Among them, there were 18 men and eight women, aged between 20 and 56 years, with an average age of 38 years. The causes of injury were cutting injuries (15 cases), sports impact injuries (nine cases), and sprains (two cases). The time interval between injury and surgery ranged from 2 hours to 48 days, with an average of 12 days. During the surgical procedure, the distal interphalangeal joint was fixed in a mild dorsiflexion position using Kirschner wire. Absorbable anchors were used to assist in the reconstruction of the insertion point of the finger extensor tendon. Additionally, a 4-0 Prolene suture was used for reinforcement.

Results: All 26 patients were followed up for a period ranging from 6 to 24 months, with an average follow-up duration of 9 months. The function of distal interphalangeal joint was preserved. According to the Crawford functional evaluation criteria, the function of the affected fingers was excellent in 15 cases, good in eight cases, fair in three cases, and poor in no cases.

Conclusions: A novel Prolene suture pull-out technique is an effective approach to repair tendon mallet finger and reconstruct the tendon-bone anatomical unit. This treatment option provides favorable outcomes, with high rates of excellent and good functional results. *(Plast Reconstr Surg Glob Open 2024; 12:e5672; doi: 10.1097/GOX.0000000000005672; Published online 1 March 2024.)*

INTRODUCTION

Mallet finger is caused by disruption of the extensor tendon I zone, which occurs when the extensor tendon is inserted into the base of the distal phalanx. Open injuries are typically the result of cutting injuries, whereas closed injuries are generally caused by sports impacts and sprains. These injuries are often accompanied by avulsion fractures of the base of the distal phalanx. Mallet finger accounts for 9.3% of all tendon and ligament injuries throughout the body and 5.6% of all tendon injuries in the wrist.[1] In cases of isolated tendon injury, the distal tendon stump is often frail and retracted, making it challenging to suture and maintain tension on the suture.[2] In our clinical practice, a significant loss of extensor function after tendon mallet finger repair was observed, which may be due to inadequate tendon bone healing caused by single-point anchor fixation. As a result, we have implemented a new surgical fixation technique combined with anchor technique to repair tendon mallet fingers. This study aimed to investigate a surgical technique that secures a modified pull-out wire at the fingertip and stabilizes the DIP joint in an overextended position using Kirschner wires, so as to improve clinical efficacy and prevent complications.

MATERIALS AND METHODS

This study included the clinical data of 26 patients with isolated tendon mallet finger who were admitted between

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January 2021 and June 2022. There were 18 male and eight female patients, ranging in age from 20 to 56 years, with an average age of 38 years. Causes of injury were as follows: 15 cases resulted from cutting injuries, nine cases from sports impact injuries, and two cases from sprains. The fingers affected by the injury were as follows: six cases involved the index finger, six cases involved the middle finger, nine cases involved the ring finger, and five cases involved the little finger. The time interval between injury and surgery ranged from 2 hours to 48 days, with an average of 12 days. The follow-up period ranged from 6 to 24 months, with an average of 9 months. The inclusion criteria were as follows: type 1–2 according to the Doyle classification system. The study population was limited to cases of isolated tendon mallet finger, with a gap of less than 1 mm from the tendon insertion site and the inability to suture the tendon. The exclusion criteria were as follows: cases combined with avulsion fracture at the insertion site and cases where the fracture was more than 1 mm away from the insertion site and could be strengthened by sutures.

We obtained anteroposterior and lateral radiographs before surgery in all cases, with the exception of avulsion fractures. The procedure was performed by the same skilled hand surgeon for all patients.

SURGICAL PROCEDURE

The patient was positioned lying supine on the hand table with the palms facing down. To begin the procedure, a tourniquet was placed over the injured finger, covering the upper arm. Before performing the procedure, we administered a digital nerve block by injecting 2 mL of 2% lidocaine. Next, we made an S-shaped or U-shaped incision dorsally to the distal interphalangeal joint. Generally, we prefer a U-shaped incision while being cautious to avoid extending beyond the nail matrix. This exposes the DIP joint and extensor tendon stump, allowing removal of the hematoma and scar surrounding the ruptured tendon. Using a 0.8-mm K-wire, we advanced it from the fingertip across the distal interphalangeal joint and secured it in slight dorsiflexion. A 1.6-mm absorbable bone anchor was then inserted on the dorsal side of the base of the distal phalanx. The anchor suture was passed through the extensor tendon using the Kessler method, and the suture was cut without knotting. We used a 4-0 Prolene Kessler or horizontal mattress suture to pass through the extensor tendon, and then cut the needle off. Next, a 5-mL syringe needle was used to pierce the fingertip from the radial side, reaching toward the end of the extensor tendon. The end of the Prolene thread was inserted into the needle tip. It was then guided along the needle channel to the fingertip, allowing for the withdrawal of the needle. The 4-0 Prolene suture was pulled out from the fingertip, and the thread on the ulnar side was guided in the same manner as the ulnar side of the fingertip. Once the suture was successfully drawn out to the fingertip, the anchor was knotted. Subsequently, the Prolene suture was passed through a 5-mm plastic tube located at the fingertip. Typically, the plastic tube is placed beneath the Kirschner wire and the securely tied to a knot on the side of the tube. For reference, please see Figure 1, which provides a back and side view of this technique.

The utilization of this surgical technique is relatively straightforward and does not excessively prolong the duration of surgery. To demonstrate its application, we provide a case that uses a surgical example (Fig. 2). Our case study involved a 39-year-old laborer who sustained an injury from contact with a rotating blade on a machine.

Takeaways

Question: This article introduces a new surgical technique for the treatment of mallet finger.

Findings: In this study, a new surgical technique was designed for tendinous mallet finger, and this technique has obvious clinical effect and fewer complications.

Meaning: This article mainly introduces a novel Prolene suture pull-out technique to improve the clinical effect and reduce the complications.

RESULTS

None of the patients were lost to follow-up. The function of the proximal interphalangeal joints and metacarpophalangeal joints was not restricted after the operation, and the Kirschner wire was removed from all patients 6 weeks after the operation. The average follow-up period was 9 months, ranging from 6–24 months. The average extensor lag in the range of motion of the distal interphalangeal joint was 2 degrees, with a range of 0 to 5 degrees. Two patients had an extension lag of up to 5 degrees, whereas 23 patients achieved full extension. The mean of flexion at the distal interphalangeal joint was 76 degrees, ranging from 64 to 86 degrees. Exercises should begin immediately after K-wire removal. Active and active-assisted range-of-motion exercises should be performed to build strength under the supervision of a certified hand therapist, without any restriction on daily activities. Full activity could be resumed on the seventh day. The Kirschner wire was removed 6 weeks after surgery, and finger flexion and extension exercises were initiated after its removal. Our patient did not require a night splint after the removal of the Kirschner wire. The Prolene sutures were removed after eight weeks. According to the Crawford evaluation criteria (Table 1), 23 patients achieved an excellent and good outcome, three patients achieved a fair outcome. There were no poor outcomes, as the surgical repair effectively covered the insertion site with the terminal tendon unit under direct vision. Sensation on the dorsal and volar aspects of the fingers did not change during the follow-up period. There were no occurrences of skin folds, masses, or tenderness on palpation. No infections, nail flap necrosis, or nail bed deformities occurred at the suture site. Radiologically, there were no signs of degenerative changes or narrowing of the joint space. Four patients reported occasional mild pain during flexion, which did not limit their daily activities.

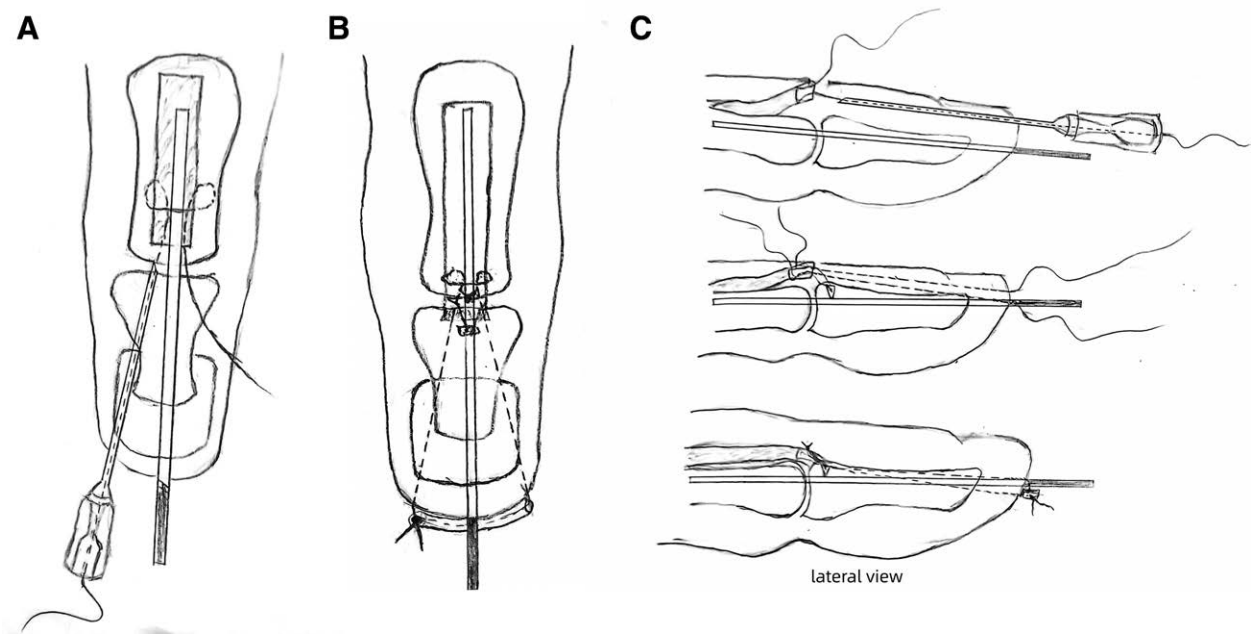

Fig. 1. The pull-out technique operation diagram. A, A 5-mL syringe needle was used to pierce the fingertip, reaching toward the end of the extensor tendon. The end of the Prolene thread is inserted into the needle tip. It is then guided along the needle channel to the fingertip. B, The tendon-bone unit is reconstructed using the bone anchor and Prolene suture pull-out technique. C, Lateral view of the Prolene suture pull-out technique.

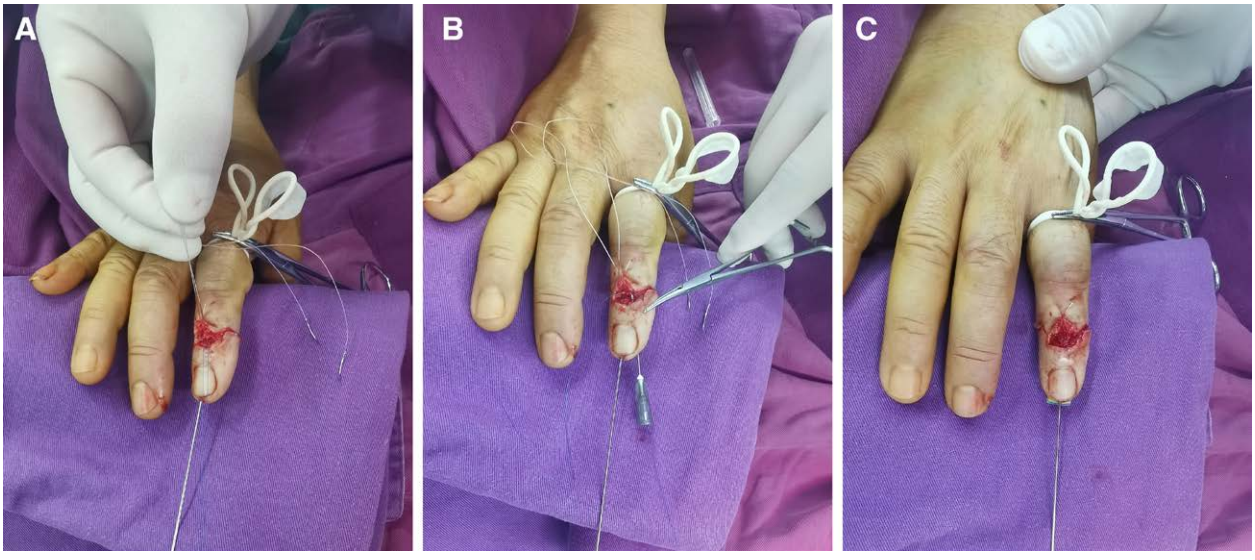

Fig. 2. A 39-year-old male patient presented with a cut wound that resulted in an index mallet finger. A, The bone anchor is inserted on the dorsal side of the base of the distal phalanx. The anchor suture is passed through the extensor tendon with a Kessler method, and 4-0 Prolene is passed through the extensor tendon with the Kessler method. B, The end of the Prolene thread is inserted into the needle tip, and then guided along the needle channel to the fingertip. C, The plastic tube is placed beneath the Kirschner wire, and then a knot is securely tied on the side of the tube.

DISCUSSION

The tendon, which is located distal to the finger extensor tendon and close to the insertion point, is both thin and superficial. An injury to this area can easily result in the rupture or tear of the finger extensor tendon from the insertion point, limiting the active dorsiflexion function of the distal interphalangeal joint and ultimately leading to the formation of mallet finger. Therefore, restoring active dorsiflexion of the interphalangeal joint and preventing swan-neck deformity are crucial for effective treatment of mallet fingers.[3] Although nonoperative management is generally recommended for most mallet finger injuries, complex cases often necessitate surgical treatment.[4] There exists some controversy regarding the

Table 1. Number of Cases that Meet Crawford Criteria for the Assessment of Mallet Finger Outcome

Grade	Characteristics of Distal Interphalangeal Joint	Number
Excellent	Full extension, full flexion, no pain	15
Good	Extension deficit 0–10 degrees, full flexion, no pain	8
Fair	Extension deficit 10–25 degrees, any flexion loss, no pain	3
Poor	Extension deficit >25 degrees, persistent pain	0

absolute indications for surgical intervention. However, the most common reasons for such intervention include open mallet finger injuries, patient noncompliance or inability to consistently use an extension splint, and involvement of large dorsal fracture fragments or metacarpal subluxation of the distal phalanx.[5]

For open tendonogenic mallet fingers, surgical repair is used to reconstruct both tendon and bony units. Closed tendonogenic mallet fingers are typically treated with splints or braces to immobilize the distal interphalangeal joint in hyperextension for 6 weeks, with generally positive outcomes. However, a study conducted by Velez[6] revealed that only seven out of 22 patients treated with splints completed the entire treatment process, and 15 of those experienced injury recurrence. The splint treatment failure rate for mallet fingers was as high as 68.2%. Based on our clinical observations, conservative treatment presents several challenges, including difficulty for patients to consistently wear the brace due to long treatment cycle, loosening of the external fixation brace over time, the inability of the tendon stump to make close contact due to finger extensor tendon retraction, which may affect the healing process and lead to a potential delay in treatment due to missed or incorrect diagnosis. Therefore, surgical intervention is necessary for patients who are unwilling to accept or who do not respond to conservative treatment. Surgical procedures are available, including scar excision and end-to-end tenorrhaphy,[7] distal interphalangeal joint fusion,[8] Kirschner wire fixation of distal interphalangeal joint hyperextension,[9] oblique retinaculum ligament reconstruction,[10] and tenodermodesis,[11] as well as partial digital deep flexor tendon reconstruction.[12] Regardless of the cause, precise restoration of the anatomical structure of the tendon and skeletal integrity is crucial for a successful outcome. The reported complication rate of mallet finger surgery was 14.5%,[3] primarily including infection, skin necrosis, nail deformity, loosening of internal fixation, osteoarthritis, joint stiffness, and tendon rupture recurrence.

The mallet finger tendon typically does not have a distal tendon stump suitable for suture. However, Ulusoy et al introduced the pull-in suture technique.[2] Although the literature reported an excellence rate of 100% with no significant complications, it should be noted that the sample size was small and the operation technique itself was relatively challenging. There was a potential risk of injury to the distal arterial arch. The new surgical technology that we adopted avoided these risks and achieved an excellent and good rate of 88.5%.

The technique presented here uses the Prolene suture pull-out technique, a surgical method that enables precise evaluation of the relationship between the distal tendon and bone. It also allows for the efficient removal of scars, debris, or callus, especially in advanced cases, and precise restoration of the integrity of the bony tendon unit with precision under direct observation. A Kessler suture with anchor suture was used to restore the bony insertion, whereas a Prolene suture pull-out technique was used to enhance the tendon-to-bone contact area and provide stronger fixation, which ensured accurate alignment and effective fixation to improve bone and tendon healing. Immediately after the removal of the Kirschner wire, the patient began active flexion and extension exercises, rendering night splints unnecessary for an additional two weeks. The pull-wire technique has proven to be beneficial for patients who face challenges with external splinting, have difficulty adhering to splinting regimens, or require an early return to low-stress work. However, it should be noted that threading the needle from the fingertip to the tendon stump necessitates a delicate surgical technique to avoid injury to the nail bed, which was not the case in our instance. This is the primary drawback of this technique. In situations where avulsion fragments are too small to fix the fracture, the Prolene suture pull-out technique can still be used to pass the suture through the tendon-bone junction and reconstruct the anatomical structure of the insertion point. The results of this technique remained highly effective. Combined with Kirschner wires, this technique offers simple and reliable intraoperative fixation, making it easier for patients to carry out daily activities and wound care management. Although complications associated with K-wire such as infection, loosening, breakage, and posttraumatic arthritis have been reported in the literature, no complications were observed in our case. Despite the reported lower complication rate of the T-shaped incision,[13] the U-shaped incision was uniformly utilized in this clinical trial, which allowed full exposure of the terminal tendon-osseous unit without any complications such as skin necrosis or ulceration. After the Prolene suture was pulled out of the fingertip, a rubber tube was placed at the fingertip before knotting to prevent the suture from cutting the skin while improving patient comfort.

In this study, a novel surgical technique was proposed using the widely acknowledged Crawford evaluation criteria. Although postoperative recovery outcomes were assessed and a high level of excellence was reported, the methodology itself remained unassessed. An important limitation of this study lies in the absence of additional comparative investigations involving alternative restoration methods. Thus, it is essential to address this aspect in future studies and further refine the approach.

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DISCLOSURES

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REFERENCES

1. De Jong JP, Nguyen JT, Sonnema AJ, et al. The incidence of acute traumatic tendon injuries in the hand and wrist: a 10-year population-based study. *Clinics Orthoped Surg.* 2014;6:196–202.
2. Ulusoy MG, Karalezli N, Koçer U, et al. Pull-in suture technique for the treatment of mallet finger. *Plast Reconstr Surg.* 2006;118:696–702.
3. Lin JS, Samora JB. Surgical and nonsurgical management of mallet finger: a systematic review. *J Hand Surg Am.* 2018;43:146–163.e2.
4. Crawford GP. The molded polythene splint for mallet finger deformities. *J Hand Surg Am.* 1984;9:231–237.
5. Hanz KR, Saint-Cyr M, Semmler MJ, et al. Extensor tendon injuries: acute management and secondary reconstruction. *Plast Reconstr Surg.* 2008;121:109e–120e.
6. Velez M, Medina MAR, Lopez RP, et al. Stack splinting versus Kirschner wire treatment in acute closed mallet finger doyle I. *Plast Surg.* 2022;30:117–121.
7. Elliott RA. Injuries to the extensor mechanism of the hand. *Orthop Clin North Am.* 1970;1:335–354.
8. Katzman SS, Gibeault JD, Dickson K, et al. Use of a Herbert screw for interphalangeal joint arthritis. *Clin Orthop Relat Res.* 1993;296:127–232.
9. Auchincloss JM. Mallet-finger injuries: a prospective, controlled trial of internal and external splintage. *Hand.* 1982;14:168–173.
10. Kleinman WB, Petersen DP. Oblique retinal ligament reconstruction for chronic mallet finger deformity. *J Hand Surg Am.* 1984; 9:399–404.
11. Iselin F, Levame J, Godoy J. A simplified technique for treating mallet fingers: tenodermodesis. *J Hand Surg Am.* 1977;2:118–121.
12. Liu H, Li R, Yuan C, et al. Treatment of tendinous mallet finger deformity with a part of the flexor digitorum profundus tendon. *Anz J Surg.* 2020;90:2325–2328.
13. King HJ, Shin SJ, Kang ES. Complications of operative treatment for mallet fractures of the distal phalanx. *J Hand Surg-Br.* 2001; 26:28–31.