Int J Burn Trauma 2018;8(2):34-39
www.IJBT.org /ISSN:2160-2026/IJBT0069905

Original Article

Treatment of mallet finger deformity with a modified palmaris longus tendon graft through a bone tunnel

Zengbing Liu[1,2], Kai Ma[1,2], Dong Huang[1]

[1]Department of Orthopaedics, Southern Medical University, Guangdong No.2 Province People's Hospital, Guangdong, China; [2]Department of Hand Surgeries, The No.4 People's Hospital of Hengshui, Hengshui, China

Received November 27, 2017; Accepted December 17, 2017; Epub April 5, 2018; Published April 15, 2018

Abstract: Objective: To investigate the clinical effect of treating mallet finger deformity using a modified palmaris longus tendon graft through a bone tunnel. Methods: Altogether, 21 patients with mallet finger deformity (16 men, 5 women; average age 31 years, range 19-47 years) were treated with a modified palmaris longus tendon graft through a bone tunnel during 18 months (2014-2016). Four index fingers, seven middle fingers, eight ring fingers, and two little fingers were treated for four cutting injuries, eleven finger sprains, four crush injuries, and two twist injuries (7 open and 14 closed injuries). Duration from injury to surgery was 9 h to 13 weeks. Three patients underwent surgery after 6 weeks of unsuccessful conservative treatment. No tendon was attached to the extensor tendon insertion in 16 patients, and 5 had residual tendon of <0.2 cm attached. All patients had distal segment flexion deformity and dorsiflexion disorder. Surgery comprised transverse penetration and vertical drilling of the base of the distal phalanx (2.0 and 2.5 mm diameter drills). Equal shallow semitendinosus pieces of the palmaris longus tendon (4 cm) were obtained from the sagittal end and were passed through a dorsal bone hole, emerging from a transverse bone hole. The two bundles were sutured to the main tendon. Tension was adjusted, and the broken ends were sutured. The distal interphalangeal joints were fixed in hyperextension. Results: All patients were followed for 7-16 months (average 6.0 ± 0.3 months) postoperatively. All 21 patients had grade A wound healing, with no complications (e.g., necrotic wound, recurrence, joint stiffness). The mallet finger deformity was corrected with good appearance, no obvious abnormalities, and satisfactory flexion and extension. Two patients had a superficial wound infection. Each recovered after symptomatic treatment. One patient had a mild result, with limited extension. There were no recurrences. Results were evaluated according to Patel et al.'s system, which revealed 15 excellent and 5 good results (combined 95.23% rate), with 1 mild result (limited extension). Patients were satisfied with the appearance and function of the affected fingers, and the desired surgical end result was achieved. Conclusion: Use of this modified surgery for treating mallet finger deformity, especially with no or little tendon attached at the extensor tendon insertion, results in nearly anatomical reconstruction of the extensor tendon insertion. Its advantages include simple surgery, reliable fixation, fewer complications, and clinical efficacy.

Keywords: Modified, bone tunnel, mallet finger, tendon graft

Introduction

Cutting, twisting, squeezing, sprain, and other injuries often lead to avulsion and fracture of the finger extensor tendon insertion. Particularly, a closed extensor tendon insertion fracture is often overlooked and not diagnosed or treated in a timely fashion, which ultimately leads to the affected finger's inability to dorsiflex the distal interphalangeal joint along with flexion deformity-i.e, mallet finger deformity [1]. In recent years, cases of mallet finger deformity have increased, but its treatment is still difficult and complex. There are several treatment methods, with different effects [2]. Between September 2014 and March 2016, our department treated 21 cases of mallet finger deformity using a self-designed, modified palmaris longus tendon graft through a bone tunnel. The results were satisfactory, with few complications.

Clinical data

The study group included 21 patients (16 men, 5 women; average age 31 years, range 19-47 years). Four index fingers, seven middle fingers, eight ring fingers, and two little fingers were

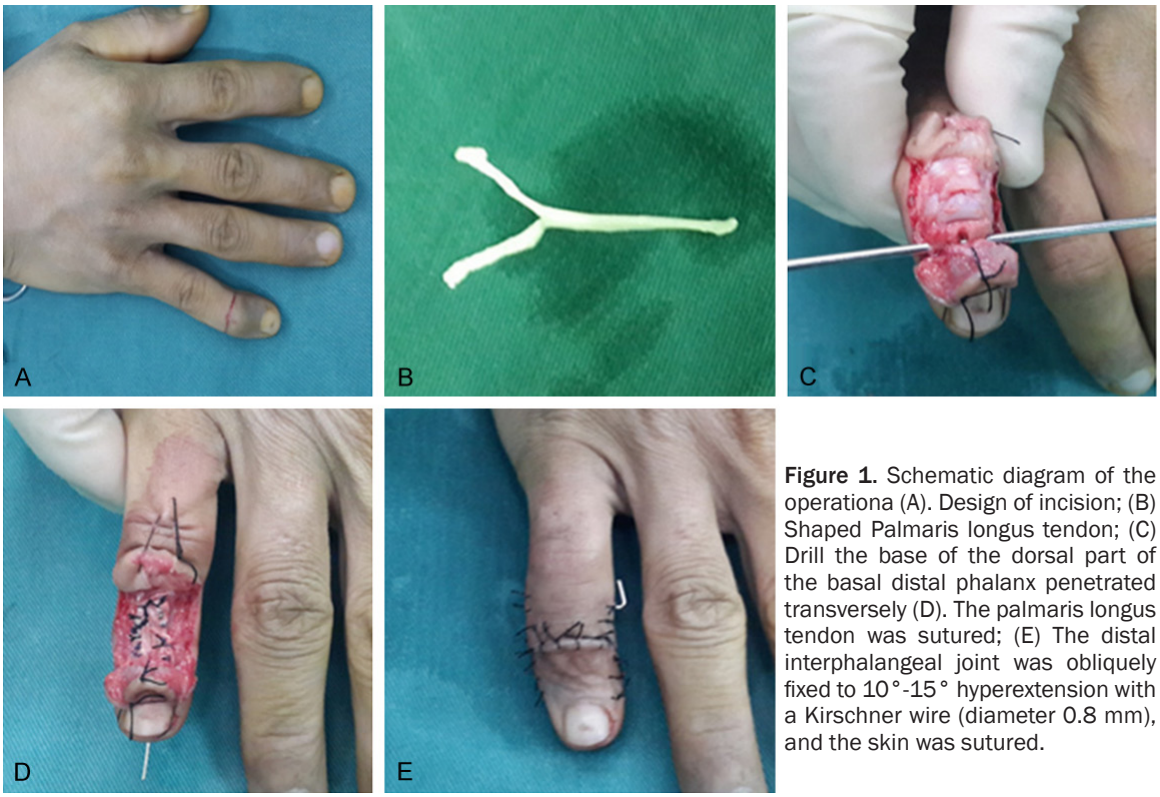

Figure 1. Schematic diagram of the operationa (A). Design of incision; (B) Shaped Palmaris longus tendon; (C) Drill the base of the dorsal part of the basal distal phalanx penetrated transversely (D). The palmaris longus tendon was sutured; (E) The distal interphalangeal joint was obliquely fixed to 10°-15° hyperextension with a Kirschner wire (diameter 0.8 mm), and the skin was sutured.

treated for 4 cutting injuries, 11 finger sprains, 4 crush injuries, and 2 twist injuries. There were 7 open and 14 closed injuries. Overall, 16 patients had no tendon attached at the extensor tendon insertion, and 5 had residual tendon of <0.2 cm. All patients had a distal segment flexion deformity and dorsiflexion disorder. The interval from injury to surgery was 9 h to 13 weeks. Three patients underwent surgery after 6 weeks of unsuccessful conservative treatment.

Treatment methods

Surgical technique

Anesthesia consisted of a brachial plexus block or a root nerve block of the affected finger. Complete hemostasis was applied. For the open injuries, the original wound was extended to fully expose the broken tendon end after appropriate, complete debridement. For the closed injuries, a dorsal "H"- or "└┐"-shaped incision was made on the distal interphalangeal joint of the affected finger, cutting through the skin and subcutaneous tissue [3]. Sharp separation was then performed to fully expose the proximal broken end of the tendon and the distal phalanx tendon insertion. (For patients with an old injury, the hypertrophic scar tissues at the broken tendon end were excised.) The proximal broken end of the tendon was trimmed. Then, using a drill (diameter 2.0 mm), the base of the dorsal part of the basal distal phalanx was penetrated transversely. Switching to a larger drill (diameter 2.5 mm) or with abrasive drilling, a hole was made in the transverse bone hole in the sagittal direction at the central dorsal part of the base of the distal phalanx, connecting to the first bone hole (without drilling through the semi-sclerotin of the palmaris longus) [4, 5]. A 4-cm, shallow semitendinosus length of the palmaris longus tendon was exposed and a sagittal section at one end of this tendon was removed in two parts. These pieces of tendon were each passed through the dorsal bone hole of the basal distal phalanx and emerged from the transverse bone hole. They were then symmetrically folded onto the proximal dorsal part and sutured to the main tendon slightly proximal to the dorsal bone hole. Tension was adjusted to 10°-15° of hyperextension of the distal interphalangeal joint [6]. The proximal end of the tendon was transplanted at the distal broken end of the extensor tendon insertion and sutured with 4-0 Covidien

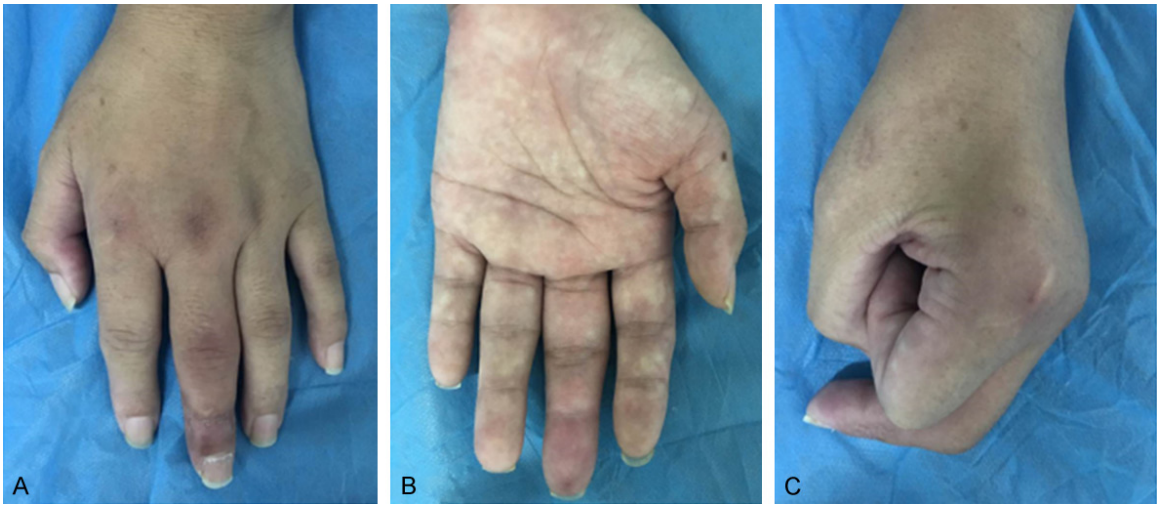

Figure 2. The appearance and function of the affected fingers. A. Palm dorsal; B. Palm side; C. The finger activity.

tendon suture line, after which the tissues surrounding the tendon were repaired [7]. The distal interphalangeal joint was obliquely fixed to 10°-15° hyperextension with a Kirschner wire (diameter 0.8 mm), and the skin was sutured (**Figure 1**).

Postoperative care

Antibiotics were given for 1-3 days, a fresh dressing replaced the soiled one on the wound regularly, and attention was paid to the wound skin to detect swelling or ulcers. Stitches were removed within 2 weeks after surgery. The Kirschner wires were removed at week 4, at which time we applied a hyperextension orthosis on the affected finger's distal interphalangeal joint for overnight fixation for 2 weeks [8]. The patient was then instructed to participate in an active and passive rehabilitation exercise regimen. Regular follow-up was conducted in the form of outpatient visits and telephone calls [9].

Results

The results were evaluated according to the mallet finger therapeutic evaluation system that was developed by Patel et al., as follows.

- The result is "excellent" when the ranges of active extension and flexion of the distal interphalangeal joint are the same as those of the other joints without injury, there is no pain in the affected finger, and the patient is very satisfied with the appearance.
- The result is "good" when, compared with the contralateral uninjured joint, the affected finger's distal interphalangeal joint has an active extension limit of <10°, there is no limitation on flexion, no pain, and the patient is satisfied with the appearance.
- The result is "mild" when, compared with the contralateral uninjured joint, the affected finger's distal interphalangeal joint has an active extension limit of 10°-20°, there is no limitation on flexion, no pain, and the patient is satisfied with the appearance.
- The result is "poor" when the patient's symptoms are not alleviated compared with the preoperative situation or with the contralateral uninjured joint, the affected finger's distal interphalangeal joint has an active extension limit of >20° and/or there is limited flexion and/or pain, and the patient is not satisfied with the appearance.

Altogether, 21 patients with a mallet finger deformity were followed up for 7-16 months, and all had grade A wound healing. None experienced complications (e.g., wound necrosis, mallet finger recurrence, joint stiffness). The mallet finger deformity was corrected with a good appearance, no obvious abnormalities, and satisfactory flexion and extension. According to Patel et al.'s evaluation system, there were 15 excellent cases, 5 good cases, and 1 mild case, with a combined excellent and good rate of 95.23%. Patients were satisfied with the appearance and function of the affected fin-

gers, and the desired surgical aims were achieved (Typical case was shown in **Figure 2**).

Discussion

Characteristics and difficulties of treating mallet fingers

The extensor tendon converges on the terminal tendon via tendon bundles on both sides in the middle of the middle phalanx and as far as the base of the distal phalanx. This part of the extensor tendon is called "zone I". Extensor tendon zone I is anatomically characterized as wide, flat, and thin with poor elasticity [10]. In case of fracture damage, the broken end is often lacerated or is avulsed from the insertion, which is frequently combined with various tendon defects. Hence, it is difficult to suture it directly because the effects of forced suturing are poor, the tendon may re-rupture, or tension may diminish, resulting in mallet finger deformity recurrence and/or joint stiffness, among other problems.

The extensor tendon of some mallet finger deformities cannot be sutured directly, especially in patients with an open injury and a partial defect of extensor tendon zone I. These cases may require insertion-site reconstruction and a tendon graft to restore the continuity of the extensor tendon structure and correct the mallet finger deformity [11]. The aim of treating a mallet finger deformity is to rebuild the extensor tendon insertion and restore extensor tendon length to achieve balance of distal interphalangeal joint flexion.

At present, there are several treatment methods for mallet finger deformity, but the effects are different. Previous methods tended to be conservative. After long-term clinical data analysis and efficacy evaluation, we found that surgical treatment can better achieve the treatment goals. Surgical treatment is increasingly being accepted and is often deemed the first choice for treating mallet finger deformity.

Advantages of this surgery

For direct suture and repair of extensor tendon zone I rupture, a prerequisite is that residual tendon of ≥ 0.2-0.3 cm for suturing at the distal broken end must be available [12]. This requirement, however, is not applicable for patients with insertion avulsion. Traditionally, for mallet finger deformity caused by insertion avulsion, the surgery comprises placing a fixation wire and rebuilding the extensor tendon insertion [13]. This surgical method, however, is often associated with a long healing time, and the repair effect is not always accurate, causing the deformity to recur due to tendon re-rupture. In addition, when removing the internal fixation wire during the secondary surgery, the wire may break and the broken wire ends may scratch the tendon, causing re-rupture. Also, clinical observations have shown that this surgery often results in nerve vascular injury and finger pulp scarring of the affected finger. Complications such as infection, pressure sores, and necrosis may also occur [14].

With the development of better materials, Mitek micro-bone anchors have come to be applied to mallet finger treatment, which further expands the surgical indications for treating mallet finger deformities. Some believe that the anchor produces greater, more severe foreign body reactions with inflammation or prolapse-at higher cost [15, 16]. Clinical observation found that some patients have exhibited immune rejection of the anchor line, so it should be used with care.

In recent years, there are reports on using palmaris longus tendon graft for treating mallet finger deformity with good results, including treatment of mallet fingers with avulsion fractures using a double loop to cross-pressurize through the tunnel for suturing, modified extensor tendon insertion for reconstruction, and treating an old mallet finger deformity by rebuilding the final tendon with a palmaris longus tendon graft. We made further improvements based on these surgical methods. The current modified surgical method has the following advantages: (1) The modified "T" bone tunnel in the transplanted tendon overcomes the issue that, with previous similar surgical methods, where there was a transverse tunnel passing through the distal phalanx's base, the tendon was triangular after passing through the tunnel and suturing, and there was the mattress suture between the two triangular bundles, resulting in longitudinal force dispersion [17]. The modified surgical method eventuates in a reconstruction that is anatomically and biomechanically more like the original extensor tendon insertion. (2) Under the conditions for a simple final insertion that there must be a dis-

tal residual <0.2 cm of tendon or none for suturing, the modified surgical method enables the tendon to connect with a relatively reliable artificial insert so the tendon is not easily avulsed. In addition, this surgical method is particularly useful in case of an extensor tendon zone I defect. (3) The use of a tendon graft does not completely cut off the musculi palmaris longus, but it reduces the injury at the tendon supply area while ensuring adequate tension of the anastomosis. (4) Because of the firm combination of the tendon and bone tunnel, the duration of postoperative intra-articular fixation is reduced from 6 weeks to 4 weeks-2 weeks less than that of conservative treatment. It is thus suitable for an early functional exercise regimen, thereby reducing the chance of joint stiffness [18]. (5) 4-0 Covidien tendon suture line and "8-shaped" suturing are used for the anastomosis of the tendon and the palmaris longus tendon, which causes less skin irritation, reducing the risk of wound infection and immune rejection. (6) The auxiliary Kirschner wire is used to fix the interphalangeal joint in the hyperextension position, which can reduce the tension of the broken end of the extensor tendon suture, creating a good, tension-free environment conducive to tendon healing. It prevents extensor tendon loss after suturing caused by flexor tendon traction. It thereby prevents secondary insufficient correction of distal interphalangeal joint flexion deformity because of the loss of tension after removing the Kirschner wire. (7) It avoids problems that occurred with previous treatments of recurrent mallet finger deformity, including incomplete deformity correction, chronic joint pain, and other complications caused by insufficient tendon strength resulting from simple tendon and joint capsule scar healing [19].

Precautions regarding this surgery

Although the process of the modified palmaris longus tendon graft through a bone tunnel is simple, improper handling of it may lead to complications, such as bone tunnel damage and insufficient tension after tendon repair. Hence, we should pay attention to the following during the operation: (1) With any intraoperative use of minimally invasive or noninvasive technology, the operation should be gentle, taking care to protect the blood supply in the skin margins and tendon tissues at the surgical site. Do not perform clumsy clamping or violent traction of the tendon and tendon film as it could cause skin margin necrosis and negatively affect the surgical incision and tendon healing. (2) The drilling position must be accurate, so strive to be successful at the first attempt, thereby preventing excessive bone loss caused by a repeated operation and by not affecting the structure of the bone tunnel. (2) When suturing a tendon, try to reduce the number of sutures while ensuring solid closure to avoid wound nonunion, skin necrosis, and postoperative adhesions caused by a severe foreign body reaction to the sutures. (3) Before suture repair of a transplanted tendon, adjust its tension to enable the distal interphalangeal joint to overextend at 10°-15°. Then, fix it with a Kirschner wire, which maintains the tension of the transplanted tendon so it does not relax after removing the external fixation. It can withstand traction of the flexor tendon, thereby reducing extensor tendon tension loss caused by flexor tendon traction [20]. (4) The surgical method has not yet been applied to children, so it is recommended that it be used in children only with caution and depending on the specific circumstances. (5) The surgical method should be used with caution in all patients, depending on the specific circumstances of the patient combined with distal phalanx fractures. (6) Postoperative functional exercise should be performed gradually so as not to cause a tendon injury due to the rush for quick results. Patients must first participate in the appropriate protective functional exercises and then increase the active and passive exercise of joints [21].

Using palmaris longus tendon transfer to reconstruct the extensor tendon final tendon insertion for treating mallet finger deformity has advantages. It is a simple operation, with little impact on surrounding normal tissues. Also, patients are satisfied with appearance of the affected finger postoperatively, and their activities are basically unrestricted (**Figure 2**). There are issues, of course-whether the tension of the transplanted tendon will gradually weaken, the long-term effect of this surgery, how to deal with tendon adhesions, joint damage caused by joint fixation, the source of blood supply for transplanting the tendon-that need further clinical discussion and research.

Acknowledgements

The authors thank Dr. Dong Huang for his valuable advice and support.We thank Nancy Schatken BS, MT (ASCP), from Liwen Bianji, Edanz Group China (www.liwenbianji.cn/ac), for editing the English text of a draft of this manuscript.

Address correspondence to: Dong Huang, Department of Orthopaedics, Southern Medical University, Guangdong No.2 Province People's Hosxpital, Guangdong, China. E-mail: huangdong-177@126.com

References

[1] Garberman SF, Diao E, Peimer CA. Mallet fi nger: Results of early versus delayed closed treatment. J Hand Surg (Am) 1994; 19: 850-852.

[2] Badia A, Riano F. A simple fixation method for unstable bony mallet finger. J Hand Surg Am 2004; 29: 1051-5.

[3] Chao JD, Sarwahi V, Da Silva YS, Rosenwasser MP, Strauch RJ. Central slip tenotomy for treatment of hronic mallet finger: an anatomic study. J Hand Surg Am 2004; 29: 216-219.

[4] Tetik C, Gudemez E. Modification of the extension block Kirschner wire technique for mallet fractures. Clin Orthop Relat Res 2002; 284-90.

[5] Gu YP, Zhu SM. A new technique for repair of acute or chronic extensor tendon injuries in zone 1. J Bone Joint Surg (Br) 2012; 94: 668-670.

[6] Bischoff R, Buechler U, De Roche R, Jupiter J. Clinical results of tension band fixation of avulsion fractures of the hand. J Hand Surg Am 1994; 19: 1019-1026.

[7] Sorene E, Goodwin D. Tenodermodesis for established mallet finger deformity. Scand J Plast Reconstr Surg Hand Surg 2004; 38: 43-45.

[8] Kronlage SC, Faust D. Open reduction and screw fixation of mallet fractures. J Hand Surg Br 2004; 29: 135-138.

[9] Rockwell WB, Butler PN, Byrne BA. Extensor tendon: anatomy, injury, and reconstruction. Plast Reconstr Surg 2000; 106: 1592-1603.

[10] Hofmeister EP, Mazurek MT, Shin AY. Extension block pinning for large mallet fractures. J Hand Surg Am 2003; 28A: 453-459.

[11] Yamanaka K, Sasaki T. Treatment of mallet fractures using compression fixation pins. J Hand Surg Br 1999; 24: 358-360.

[12] Makhlouf VM, Deek NA. Surgical treatment of chronic mallet finger. Ann Plast Surg 2011; 66: 670-672.

[13] Ulkür E, Açikel C, Ergun O, Celiköz B. Repair of chronic mallet finger deformity using Mitek micro arc bone anchor. Ann Plast Surg 2005; 54: 393-396.

[14] Teoh LC, Lee JY. Mallet fractures: a novel approach to internal fixation using a hook plate. J Hand Surg Br 2007; 32: 24-30.

[15] Husain SN, Dietz JF, Kalainov DM, Lautenschlager EP. A biomechanical study of distal interphalangeal joint subluxation after mallet fracture injury. J Hand Surg (Am) 2008; 33: 26-30.

[16] Ulusoy MG, Karalezli N, Koçer U, Uysal A, Karaaslan O, Kankaya Y, Aslan C. Pull-in suture technique for the treatment of mallet finger. Plastic Reconst Surg 2006; 118: 696-702.

[17] Crawford GP. The molded polythene splint for the mallet finger deformities. J Hand Surg (Am) 1984; 9: 231.

[18] Haagsma A, de Boer HL, Quintus AC, Strikkeling NJ, Zeebregts CJ, Smit JM. Treatment of mallet fingers in Dutch hospitals: a nationwide survey of practice. Eur J Emerg Med 2015; 22: 211-214.

[19] Okafor B, Mbubaegbu C, Munshi I, Williams DJ. Mallet deformity of the fingerVfiveyear follow-up of conservative treatment. J Bone Joint Surg Br 1997; 79: 544-547.

[20] Kakinoki R, Ohta S, Noguchi T, Kaizawa Y, Itoh H, Duncan SF, Matsuda S. A modified tension band wiring technique for treatment of the bony mallet finger. Hand Surg 2013; 18: 235-242.

[21] Rocchi L, Genitiempo M, Fanfani F. Percu-taneous fixation of mallet fractures by the "umbrella handle" technique. J Hand Surg Br 2006; 31: 407-412.