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*Case Report*

# Bony mallet finger: a novel surgical approach to the terminal tendon insertion using a dual parallel incision - A case series study

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**Abstract:** A bony mallet finger refers to an avulsion fracture at the dorsal base of the distal phalanx. When the fracture fragment involves more than one-third of the articular surface and is accompanied by volar subluxation of the DIP joint, the joint's stability is compromised. In this setting, surgical treatment is often necessary. Open reduction and hook plate fixation provide the most rigid fixation and have become increasingly popular. However, surgical approaches - including Y-, H-, S-, and U-shaped incisions - are frequently associated with complications such as skin necrosis, nail deformity, and implant extrusion. Treating bony mallet finger with a hook plate is challenging. This retrospective case series study involved a review of 26 patients who underwent surgical treatment for bony mallet finger between May 2019 and December 2022. Our objective is to describe a novel surgical approach using double parallel dorsal longitudinal incisions for fixing mallet fractures. Additionally, we provide the preliminary results to evaluate its effectiveness.

**Keywords:** Mallet fracture, incision, hook plate, open reduction and internal fixation, nail deformity

## Introduction

A bony mallet finger refers to an avulsion fracture at the dorsal base of the distal phalanx. Although the extensor terminal tendon remains attached to the avulsed bone fragment, the distal interphalangeal joint (DIP) cannot be actively extended due to disruption of the extensor mechanism at its terminal insertion. When an axial load is applied to the extended DIP joint, hyperextension of the DIP joint can result in a bony mallet finger or mallet fracture, whereas excessive palmar flexion of the DIP joint can cause a tendinous mallet finger.

One-third of all mallet finger injuries are associated with a fracture [1]. When the fracture fragment involves more than one-third of the articular surface and is accompanied by volar subluxation of the distal interphalangeal (DIP) joint, the stability of the DIP joint is compromised, indicating the need for surgical treatment [2, 3]. If left untreated, this condition can lead to secondary swan neck deformity, premature osteoarthritis, pain and joint stiffness [4-6]. Open reduction and hook plate fixation provide the most rigid fixation and have become increasingly popular [7, 8].

But due to the thin skin over the extensor terminal tendon and the fracture is adjacent to the nail matrix, surgical incision located in an exposed area and numerous complications, using a hook plate to treat bony mallet finger is challenging [9, 10].

The primary objective of this retrospective study was to describe a novel technique using double parallel dorsal longitudinal incisions for exposure and hook plate fixation to treat bony mallet finger, Secondly, we provided preliminary descriptions of the clinical and radiological results obtained with this technique to assess its effectiveness.

## Materals and methods

This retrospective case series study involved a review of 26 patients who underwent surgical treatment for bony mallet finger between May

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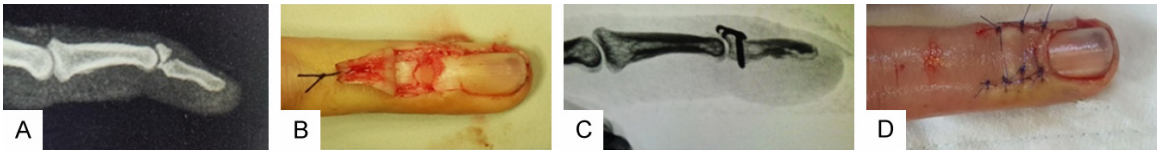


**Figure 1.** The novel dual parallel incision and plate fixation. A. Wehbe and Schneide type C bony mallet finger. B. Dorsal double longitudinal incision and exposure. C. Fixation with a single-hole hook plate. D. Incision closure.

2019 and December 2022 in a single level II Trauma Center. The study was approved by the organization's ethical committee (Ethics Review Committee of Beijing Shunyi District Hospital) under No. QR-112-045-1611. Informed consent was obtained from all participating patients. The inclusion criteria comprised patients of both genders with a history of acute traumatic injury within the previous 10 days and no surgical intervention; no recent injury to the affected finger; and no previous or current inflammatory diseases, such as rheumatoid arthritis, or degenerative diseases of the fingers. Only those categorized as type B or type C according to the Wehbe-Schneider classification (fractures involving more than one-third of the distal phalanx articular surface on the lateral x-ray of the digit) [11] were included. The exclusion criteria comprised patients with open finger injuries, adolescents under the age of 16, and those with multiple fingers injured simultaneously.

*Surgical technique*

Patients were placed in the supine position and administered digital nerve block anesthesia. A finger tourniquet (Penrose drain) was used to control bleeding during the procedure. A double longitudinal parallel incision was made on the dorsal side of the fingers, starting at the intersection of the lateral and proximal nail folds and extending to the DIP joint. Using 2.5× surgical loupes, the connection between the nail epithelium and the nail plate was meticulously dissected. The skin was then elevated from the terminal tendon to form a rectangular anterograde skin flap. The flap was turned upside down and fixated to the dorsal skin of the middle phalanx with sutures to fully expose the structures of the nail matrix, nail root, base of the distal phalanx, and the dorsal extensor terminal tendon insertion. After identifying the distal phalanx fracture fragment and the distal portion of the extensor terminal tendon, the fracture was reduced under direct visualization and stabilized with a 1.0 mm Kirschner wire tip placed against the fracture fragment. A low-profile single-hole hook plate (height 0.55 mm, length 4.0 mm, 1.7-mm non-locking hook plate, Stryker™) was then positioned, with the hook passing through the terminal tendon to capture the dorsal edge of the avulsed bone fragment. Part of the nail matrix was sharply dissected subperiosteally to accommodate the hook plate. After predrilling, a 1.7 mm cortical screw was used to secure the plate to the shaft of the distal phalanx. The patient actively moved the DIP joint. Intraoperative observation and fluoroscopy confirmed that the fracture was firmly fixed without separation. The dissected nail matrix was then repositioned to cover the distal end of the plate. After cleaning the wound with 0.9% saline, releasing the tourniquet, and ensuring local hemostasis, the incision was sutured with 4-0 non-absorbable polypropylene suture (PROLENE™), and a dressing was applied. No splint was required during the postoperative period (**Figure 1**).

*Postoperative care and follow-up*

The dressing was changed three days after the intervention. The patients were discharged and followed up weekly; stitches were removed in the second week. Thereafter, patients were instructed to begin rehabilitation under the supervision of physiotherapists. Posteroanterior and lateral X-rays of the fingers were taken at the fourth week after the operation and then monthly until bone union was confirmed (the fracture line disappeared, and bridging trabeculae passed through the fracture line).

At 4, 8, and 12 months postoperatively, patients were assessed for their level of satisfaction with the treatment according to the criteria proposed by Crawford (Excellent: no extension lag, full flexion, no pain. Good: extension lag <10°, full flexion, no pain. Fair: extension lag 10°-25°, any loss of flexion, no pain. Poor: extension lag >25°, any loss of flexion, persistent pain. Range

of motion and extension lag at the DIP Joint were measured with a goniometer) [12]. The time taken for patients to return to work was recorded, and pain in the injured finger was evaluated using the Visual Analogue Scale (VAS) where 0 is no pain and 10 is unbearable pain. At the final follow-up, Posteroanterior and lateral X-rays of the fingers were obtained to identify any degenerative changes at the DIP joint, such as osteoarthritis or dorsal osteophytes of the distal phalanx. The presence of nail deformities was observed and documented at each follow-up. If a nail deformity was detected, the hook plate was removed four months after surgery.

The range of motion (ROM) of the DIP joint, fracture healing time, time to return to work, and other quantitative variables were described using the median and range. Qualitative variables, such as treatment effects and complications, were reported as frequencies and percentages. The DIP joint ROM of the injured finger was compared with that of the contralateral normal finger using a paired-samples t-test to assess for significant differences. Statistical analysis was performed using SPSS (Statistical Package for the Social Sciences) version 17.0, with a *p*-value of less than 0.05 considered statistically significant.

## Results

In the current study, 32 patients with bony mallet fingers were treated using double dorsal digital longitudinal incision exposure and hook plate fixation between May 2019 and December 2022. Four patients with a history of acute traumatic injury beyond 12 days and two elderly patients (aged 60 and 62) with significant osteoarthritis and joint degeneration deformities prior to injury were excluded. Ultimately, 26 patients were included in the study. Of these, 20 (77%) were male and 6 (23%) were female. The mean age was 28 years (range, 18 to 52 years). The follow-up period ranged from 6 to 24 months, with a mean of 12 months. Sixteen patients (62%) had the injury in the right dominant hand, while 10 (38%) in the left non-dominant hand. Three patients (11%) had involvement of the second digit; nine (35%) the third digit; ten (39%) the fourth digit; and four (15%) the fifth digit. There were 19 (73%) cases of type B and 7 (27%) type C according to the Wehbe and Schneider classification. The mean time from injury to operation was 3 days (range, 2 to 9 days). The mean time to fracture union was 8 weeks (range, 4 to 9 weeks). The DIP joint extension lag was 0° (range, 0° to 15°), and the active DIP joint flexion angle was 80° (range, 70° to 90°). Postoperative DIP joint range of motion averaged 80° (range, 65° to 85°). The mean time to return to the original occupation was 8 weeks (range, 4 to 9 weeks). There was no significant difference in DIP joint range of motion between the injured finger and the contralateral finger ($t = -0.652$, $P = 0.52$). No patients exhibited DIP osteoarthritis at the final follow-up, although one patient reported mild DIP joint pain at work (VAS score 3). According to the Crawford criteria, 15 cases (58%) had excellent results, 10 cases (38%) had good results, and 1 case (4%) had fair results. There were no poor outcomes, no skin infection or necrosis. All wounds healed uneventfully without dehiscence, ulcer or necrosis. The complication rate in our patient series was 19%, including DIP joint extension lag, nail deformity, and plate loosening.

Two weeks after surgery, when removed the incision stitches in one case, the hook plate and screw were found to be loose, with localized pain and swelling, although the wound healed without complications. The fracture fragment was reduced by percutaneously compressing the loosened plate. A finger splint was applied to prevent further loosening. After fracture union was confirmed by X-ray at nine weeks post-operation, the splint was removed, and began rehabilitation under the supervision of a physiotherapist. The final follow-up revealed a 15° DIP joint extension lag, and had a mild local pain during work, with a VAS score of 3. This was the only case of fair outcome in this group (**Figure 2**).

Four patients (15%) experienced nail deformities, which gradually resolved or improved following the removal of the hook plate and screw four months after the initial surgery (**Figure 3**).

## Discussion

Regardless of the device used for osteosynthesis - whether a plate, Kirschner wire, screw, or steel wire - surgical treatment is the most appropriate choice in cases where the mallet

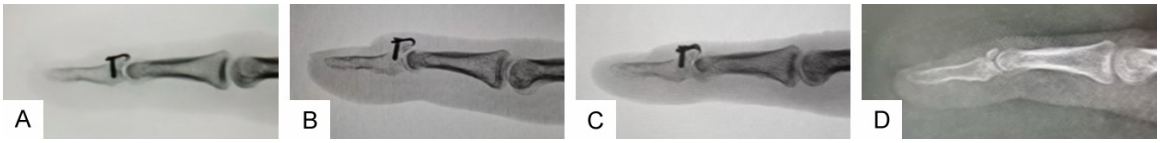


**Figure 2.** The loosened fixation case. A. The screw did not penetrate the contralateral cortex, and the screw purchase was weak. B. Fixation failed 2 weeks post operation and the reduction was lost. C. The reduction was achieved by closed squeezing the plate. D. The plate was removed 4 months after operation and the fracture healed.

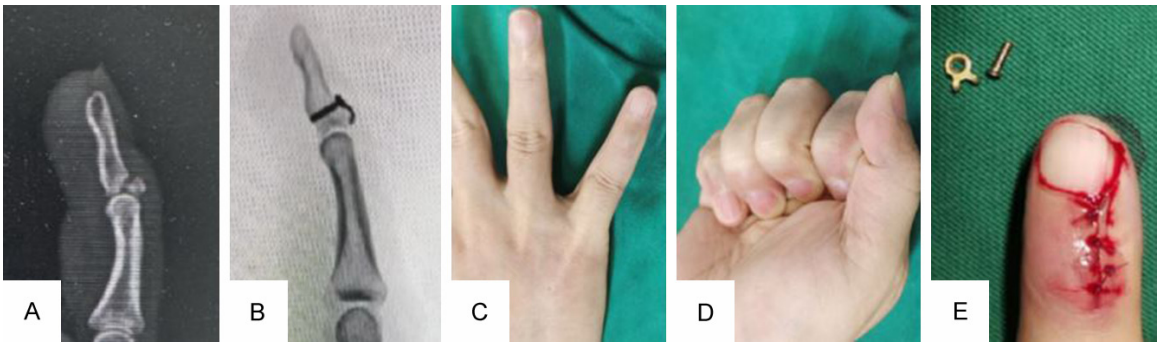


**Figure 3.** One of nail deformity case. A. The right little finger had a bony mallet fracture. B. Fixation with hook plate using the novel incision technique. C, D. Four months after operation, the DIP joint had fully estention and flexsion, but the nail had a mild deformity. E. Removed the implant using one of the original double parallel longitudinal incisions.

fracture fragment involves more than one-third of the articular surface.

Teoh LC [13] first described an innovative technique in 2007 to manage mallet fractures using a hook plate (fabricated from a straight AO 1.3 hand modular system titanium plate). In their study of nine patients, all had good to excellent outcomes according to the Crawford criteria. All patients were satisfied with the postoperative range of motion (ROM) of the DIP joint, reporting nearly normal flexion without any extension lag. However, there cases had a nail deformity. Patients could perform DIP joint flexion and extension after surgery due to stable, rigid fixation. Utilizing the tension band principle, the hook plate is positioned on the dorsal side of the distal phalanx. This approach eliminates the need for trans-articular pinning, and facilitates early mobilization, improves patient comfort, acceptability, and compliance. Since then, Open reduction and hook plate fixation have become increasingly popular.

With the widespread use of the hook plate for mallet fracture treatment, there has been an increased rate of related incision complications, including plate extrusion, skin necrosis, and screw loosening [2, 5, 7].

To the best of our knowledge, there are several surgical approaches that have been used to expose the mallet fracture fragment, including Y-, H-, S-, and U-shaped incisions. These incisions create a retrograde flap on the dorsal side of the distal phalanx. By retracting the flap distally, the nail matrix, nail root, dorsal base of the distal phalanx, fracture fragment, and terminal extensor tendon are exposed. However, exposure of these structures is often insufficient, and prolonged traction of the retrograde flap can cause ischemia during surgery by the above incisions, leading to skin necrosis and postoperative extrusion of the internal fixation plate. Lee JI [14] employed a U-shaped skin incision in 7 cases, one patient developed dorsal skin ulceration and metal plate exposure two weeks after surgery. This patient underwent revision surgery with extension block pinning after plate removal but subsequently achieved only 50% of the total active motion compared to the contralateral finger. Hossam Abubeih [15] treated 17 cases of bony mallet fingers using a U-shaped incision, two cases developed wound infections post-surgery, both of which were managed with debridement and removal of the metal implant. At the final follow-up, both patients exhibited limited range of

motion and extension lag, resulting in fair outcomes according to the Crawford scale. Tie J [16] employed a hook plate with an H-type skin incision, however, three of 29 patients experienced transient skin flap ischemia. Gabor Szalay [17] utilized a typical Y incision, which led to two cases of skin perforation among 59 patients. H. J. King [18] reported 59 cases of surgical treatment for bony mallet fingers; 24 (41%) developed postoperative complications, with the most common being marginal skin necrosis on the dorsal aspect of the distal phalanx.

We believe that the Y-, H-, S-, and U-shaped skin incisions all create a transverse incision on the dorsal skin of the DIP joint, due to the tension caused by DIP joint flexion, the incision is pulled both distally and proximally, which impairs wound healing. Consequently, there is an increased risk of wound infection, ulcer, dehiscence, and extrusion of internal fixation plates.

The skin over the dorsal aspect of the DIP joint is thin, has limited malleability, and contains almost no subcutaneous adipose tissue, making surgical incisions in this area and ensuring uneventful healing has a significant challenge. Due to the inherent limitations of the previously described Y-, H-, S-, and U-shaped skin incisions, we adopted a double longitudinal incision on the dorsal aspect of the distal phalanx. This novel incision technique offers several advantages: (1) Improved direct visualization exposure. By meticulously dissecting the flap between the two incisions - from the proximal nail fold to the DIP joint - it can fully exposes all structures around the terminal extensor tendon insertion, providing superior exposure compared to Y-, H-, S-, and U-shaped incisions. (2) Protection of skin blood supply. The blood supply to the rectangular skin flap created by the double longitudinal incisions is anterograde, fully maintaining the dorsal skin's vascular. The flap is secured to the dorsal skin of the middle phalanx with sutures, avoiding prolonged traction which can cause transient ischemia. (3) Prevention of venous congestion. Since no subcutaneous veins are transected, venous congestion is avoided, which can promote better wound healing. (4) Facilitation of DIP joint motion. The longitudinal incision aligns with the tension lines on the dorsal side of the DIP joint, allowing both active and passive joint movement early in the postoperative period without concerns about wound dehiscence or ischemic nonunion. None of our 26 patients experienced complications such as wound skin necrosis or plate exposure.

In one of our cases, loss of reduction occurred two weeks after surgery due to screw loosening and plate fixation failure. The screw length used in this patient's plate fixation was 5 mm and did not penetrate the contralateral cortex of the distal phalanx. We percutaneously compressed the screw and plate, and fortunately, this maneuver nearly restored the fracture reduction. Wang WC [19] reported that one case of bony mallet finger hook plate fixation experienced screw loosening and fixation failure due to improper screw positioning. They suggest that for fractures involving more than 40% of the articular surface, the screw trajectory should be angled toward the fingertip to increase screw length and enhance screw holding strength. When the screw length is less than 5 mm, it cannot fully counteract the pulling force of the extensor tendon. So in subsequent cases, we deliberately increased the screw length by 1 mm to ensure the screw tip passed through the contralateral cortex to improve screw purchase. Following this adjustment, no further loss of reduction occurred.

Nail deformity is a common complication following mallet finger surgery, particularly when using hook plate fixation, with an incidence rate of 33% [19]. In our study, there were 4 cases (10.5%) of nail malformation. This deformity resembles the nail groove caused by compression of the nail matrix with a mucous cyst located on the dorsal aspect of the DIP joint. Schweitzer [20] measured the fingers of 56 cadavers and reported an average distance of 1.4 mm (range, 0.9-2.0 mm) between the distal end of the terminal tendon and the proximal edge of the germinal matrix. The insertion length of the terminal tendon was 1.2 mm (range, 0.8-1.7 mm) when extended distally from the articular surface. Therefore, when a hook plate (4 mm in length) is placed on the dorsal side of the distal phalanx, part of the nail matrix must be elevated subperiosteally to accommodate the distal end of the plate; otherwise, the nail germinal matrix will inevitably be compressed.

This study has several limitations, including the absence of a control group, a retrospective design, and a short follow-up period. However, the study used a consecutive series of patients, demonstrating that double dorsal digital longitudinal incision exposure combined with hook plate fixation for treating mallet fractures yielded satisfactory clinical outcomes.

## Conclusion

This novel double dorsal digital longitudinal incision technique provides direct visualization and fully exposure of all structures around the terminal tendon insertion while protecting the skin's blood supply simultaneously. It prevents venous congestion and facilitates motion of DIP joint, minimizing incision complications such as local skin ischemia, necrosis, infection, and implant plate extrusion. The robust fixation by the hook plate allows earlier rehabilitation after surgery, which promotes fracture healing, enabling a quicker return to work, and ensuring good patient compliance along with a high level of comfort. Therefore, for young patients with bony mallet fingers who are eager to return to work, double dorsal digital longitudinal incision exposure combined with hook plate fixation is a recommended treatment option.

## Disclosure of conflict of interest

None.

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