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DYNAMIC EXTERNAL FIXATION USING SUZUKI FRAME FOR MIDDLE PHALANX BASE FRACTURE WITH ASSOCIATED MALLET FRACTURE OF THE INDEX FINGER: A CASE REPORT

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ABSTRACT:
Background: A combined injury pattern involving a bony mallet fracture at the distal interphalangeal (DIP) joint and an intra-articular fracture of the base of the middle phalanx associated with dorsal subluxation of the proximal interphalangeal (PIP) joint is rarely encountered. The involvement of two adjacent finger joints makes restoration of alignment and early functional recovery particularly challenging. Inadequate reduction and prolonged immobilization can lead to extensor lag, joint stiffness, persistent pain, and post-traumatic arthritis. The Suzuki dynamic external fixation system provides a minimally invasive approach to maintain PIP joint reduction while facilitating early mobilization.
Case Report: A 36-year-old male presented with pain, swelling, and deformity of the left index finger following trauma while playing cricket. Radiographs revealed a bony mallet fracture involving the distal phalanx and an intra-articular middle phalanx base fracture with dorsal PIP joint subluxation. The patient underwent K-wire fixation for the mallet fracture and Suzuki frame dynamic external fixation for the PIP fracture-dislocation. Early active motion was initiated postoperatively.
Results: At six weeks, radiological union and maintenance of reduction were observed. At three months, the patient achieved PIP flexion greater than 90°, extensor lag less than 5°, painless grip function, and return to pre-injury activities.
Conclusion: This case highlights the unusual presentation of simultaneous bony mallet injury with proximal interphalangeal joint fracture dislocation in the same digit.
Hybrid fixation using k wire pinning and Suzuki frame dynamic external fixation is an effective treatment option for combined DIP and PIP joint injuries. It provides stable fixation, allows early mobilization, and yields good functional outcomes.

KEYWORDS: Suzuki frame, mallet fracture, PIP fracture-dislocation, dynamic external fixation, hand trauma,

INTRODUCTION

Mallet finger injuries result from disruption of the terminal extensor mechanism at the distal phalanx and may occur with or without an associated bony avulsion fragment. Surgical treatment is generally recommended when the fracture involves more than one-third of the articular surface or is associated with volar subluxation of the distal phalanx.[1]
Fracture-dislocations of the PIP joint involving the base of the middle phalanx are complex injuries that often result in instability, stiffness, and post-traumatic arthritis if inadequately treated.[2,3] The primary goals of treatment are restoration of articular congruity, maintenance of joint stability, and early mobilization.
The simultaneous occurrence of a mallet fracture and middle phalanx base fracture-dislocation in the same digit is uncommon and sparsely reported in the literature. We present a case successfully managed using a combination of extension-block pinning and Suzuki frame dynamic external fixation.

Case Report

A 36-year-old right-hand-dominant male presented to our institution with pain, swelling, and deformity of the left index finger following trauma sustained while playing cricket. On clinical examination, the left index finger showed diffuse swelling predominantly involving the proximal interphalangeal (PIP) and distal interphalangeal (DIP) joints, with associated redness. There was no laceration, scar, sinus, or other evidence of an open injury. Local tenderness was elicited over both the PIP and DIP joints, with painful restriction of range of motion at both joints. A flexion deformity was noted at the DIP joint, which was passively correctable but associated with pain. The metacarpophalangeal (MCP) joint had a range of motion from 0° to 90°, with pain beyond this range. Distal neurovascular examination was normal, with intact sensation and adequate distal perfusion.

Radiographic Evaluation

Radiographs of the left index finger ap and lateral view revealed:

1)Avulsion fracture of the base of distal phalanx on the dorsal aspect

2) Intra-articular fracture of the base of the middle phalanx with Dorsal subluxation of the proximal interphalangeal joint.

Figure 1. Pre-operative x-ray left index finger ap and lateral view showing middle phalanx base fracture-dislocation with associated bony mallet fracture.

Figure 2. Additional pre-operative left hand ap and oblique view demonstrating articular involvement and dorsal PIP subluxation.

Surgical Technique

The procedure was performed under wrist block. Closed reduction and k wire fixation using 1mm k wire of the mallet fracture was done under C arm guidance. The proximal interphalangeal joint fracture dislocation was treated using a dynamic external fixator. A 1.2 mm long k wire was passed through the center of rotation in the head of proximal phalanx (axial traction pin). Secondly another 1.2 mm K wire was passed through the head of middle phalanx (hook pin). A third 1.2mm k wire was passed through the middle phalanx closer to the fracture site to correct the dorsal displacement (reduction pin). A elastic band was connected between the axial traction pin and hook pin to provide traction across the fracture site. This aids in the alignment of the fracture fragments and mobilization of the joint immediately. Reduction was checked under C arm. Sterile dressing was applied.

Figure 3. Intra-operative clinical image demonstrating Suzuki frame application.

Figure 4. Intra-operative C-Arm image confirming restoration of joint congruity.

Functional outcome criteria

For a PIP joint fracture-dislocation with mallet bone fracture treated hybrid fixation strategy using k wire fixation of mallet injury with dynamic external fixation of the proximal interphalangeal joint, two useful ways of reporting functional outcome are Total Active Motion (TAM) and the Crawford classification.

1. Total Active Motion (TAM)

TAM measures the total amount of active flexion of the finger, while accounting for extension deficits.

Formula

TAM = MCPF + PIPF + DIPF − ED

Where:

MCPF = maximum active MCP flexion

PIPF = maximum active PIP flexion

DIPF = maximum active DIP flexion

ED = extension deficit at that joint

Interpretation

A commonly used interpretation is:

TAM	Functional result
> 240°	Excellent

220–239°	Good
180–219°	Fair
<180°	Poor

2. Crawford Classification

Crawford classification is primarily used to assess the functional outcome of mallet finger, based on the patient's ability to actively flex and extend the DIP joint.

It evaluates two things:

Extension deficit at the DIP joint

Flexion ability at the DIP joint

Crawford grading

Grade	Finding
Excellent	Full extension and full flexion
Good	Extension deficit <10°
Fair	Extension deficit 10–25°
Poor	Extension deficit >25° or significant loss of flexion

POST OPERATIVE

Postoperatively, immediate controlled mobilization of the PIP joint was initiated to minimize stiffness and maintain joint mobility. The patient was treated with oral analgesics and antibiotics, and limb elevation was advised to reduce postoperative swelling. Daily pin-site care was performed. Controlled PIP joint range-of-motion exercises were continued from the immediate postoperative period. Elastic band tension was adjusted appropriately during follow-up visits.

The Suzuki frame was removed at 6 weeks, while the K-wire used for fixation of the mallet fracture was removed at 8 weeks. At the 6-week follow-up, fracture union was progressing satisfactorily, with maintained reduction and no evidence of pin-tract infection. The patient had residual stiffness, with PIP joint flexion initially limited to approximately 90°, which gradually improved with physiotherapy.

At the 3-month follow-up, PIP joint flexion had improved to more than 90°, with no residual DIP extensor lag. A full functional grip was restored. The patient reported no pain or instability and was able to perform all routine daily activities. The patient remains under follow-up.

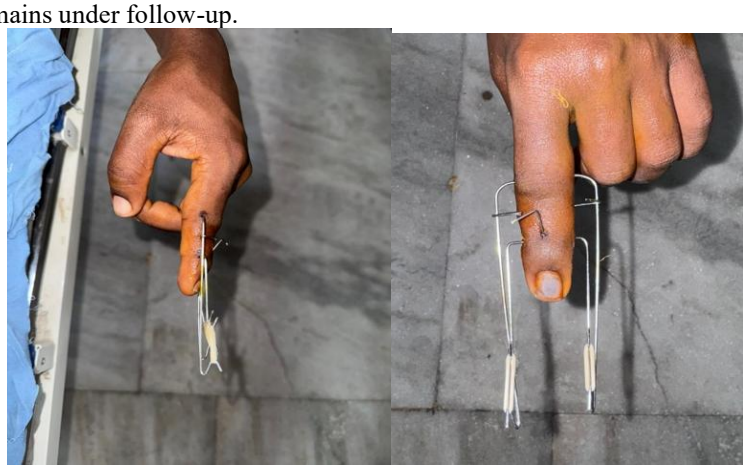

Figure 5. Clinical photograph at one week postoperatively showing Suzuki frame in situ.

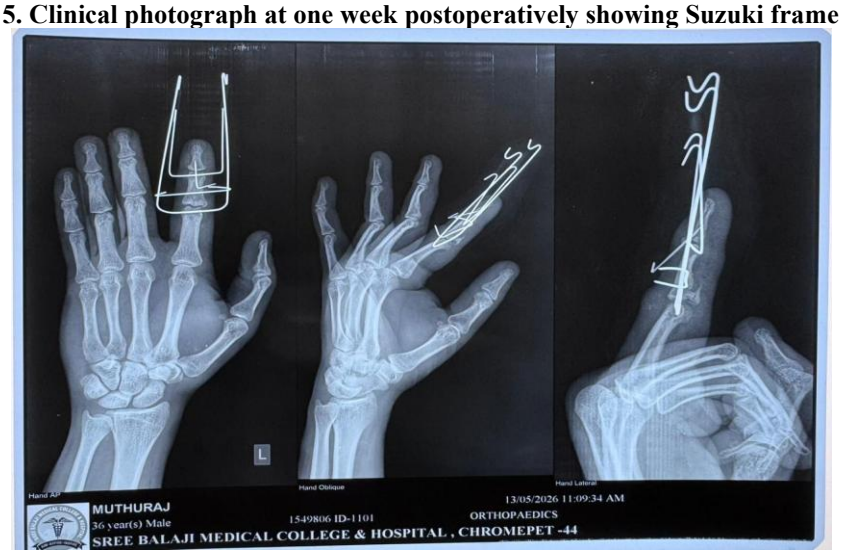

Figure 6. Follow-up at one week x-ray hand ap and oblique view and index finger latera view demonstrating fracture union and maintained alignment.

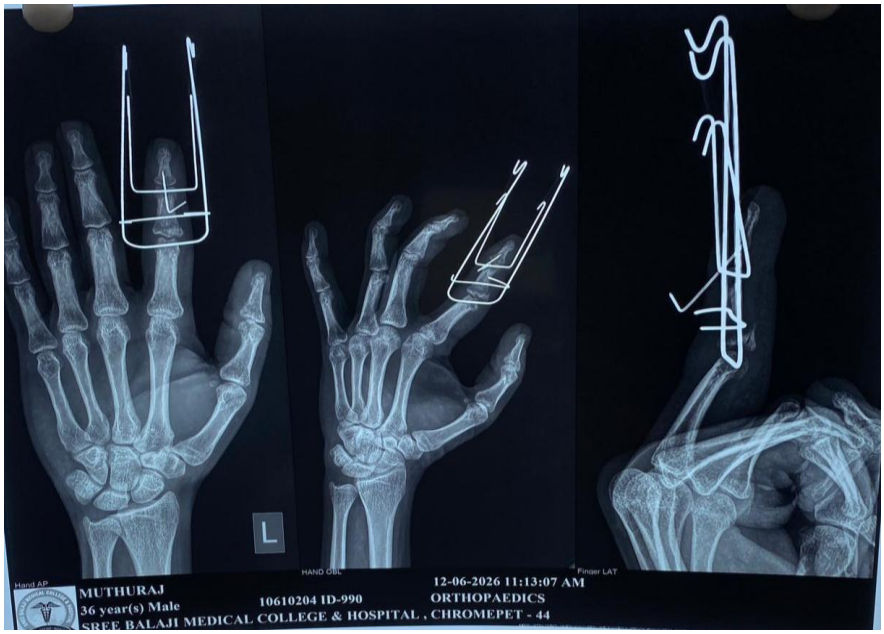

Figure 7. Post-operative follow-up at one month x-ray hand ap and oblique view and index finger demonstrating the Suzuki dynamic external fixation frame with maintained reduction of the index-finger PIP fracture-dislocation.

Figure 8. Follow-up at 8 week of the left index finger ap and lateral view demonstrating maintained alignment with progressive fracture healing after Suzuki frame and k-wire removal.

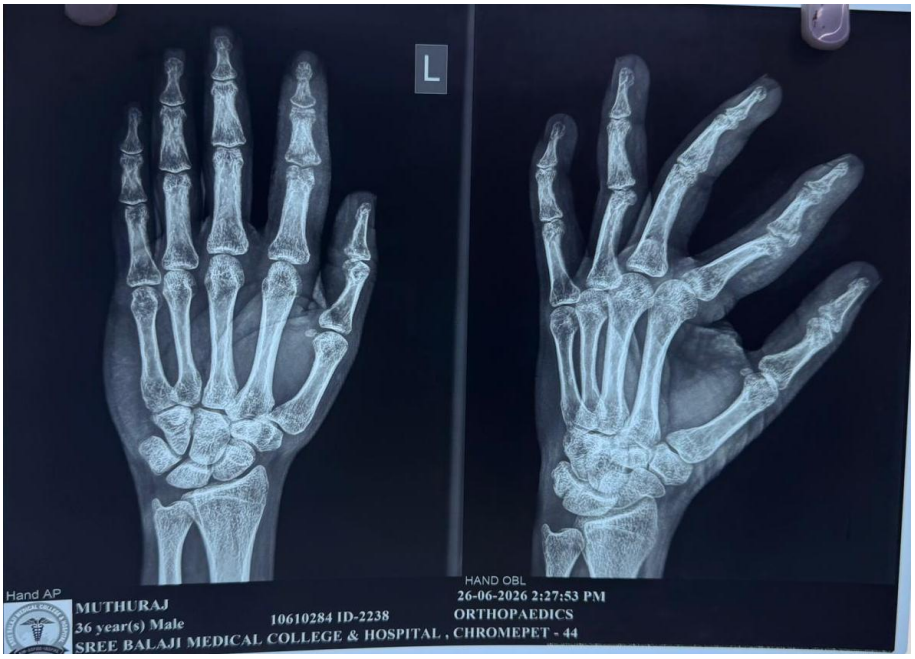

Figure 9. Follow-up x-ray hand AP and oblique view of the left hand demonstrating maintained reduction and satisfactory healing following removal of the fixation.

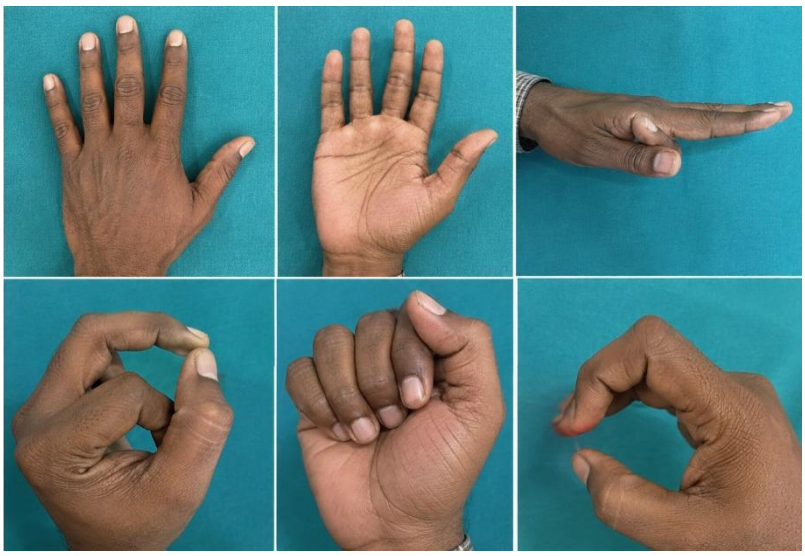

Figure 10. Clinical photographs at 3 months follow up after removal of Suzuki frame and k-wire showing well healed surgical site. The patient has regained satisfactory range of motion at PIP and DIP joint of the INDEX FINGER with no extensor lag. Functional grip and pinch are good. No swelling or deformity noted.

DISCUSSION

The present case represents an uncommon and challenging combination of an intra-articular fracture-dislocation of the proximal interphalangeal (PIP) joint associated with a dorsal avulsion fracture of the base of the distal phalanx (bony mallet injury) in the same index finger. Simultaneous injuries involving both the PIP and distal interphalangeal (DIP) joints are clinically important because each lesion has different biomechanical and treatment considerations. The PIP fracture-dislocation is particularly prone to instability, articular incongruity, stiffness, and post-traumatic arthritis, while an associated mallet fracture may result in persistent extensor lag or DIP flexion deformity if inadequately reduced and stabilized.

PIP joint fracture-dislocations are commonly produced by an axial load combined with hyperextension or flexion forces. In the present case, the intra-articular fracture of the base of the middle phalanx with dorsal subluxation of the proximal phalanx indicates disruption of the volar buttress of the middle phalanx and loss of normal PIP joint stability. The extent of articular surface involvement and the degree of dorsal subluxation are important determinants of stability. When the fracture fragment is sufficiently large or the joint remains unstable after reduction, simple immobilization may be inadequate. Prolonged immobilization, although capable of maintaining reduction, may lead to significant PIP stiffness and poor functional outcome, particularly because the PIP joint is highly susceptible to contracture.

The associated dorsal avulsion fracture at the base of the distal phalanx represents a bony mallet injury, resulting from disruption of the terminal extensor mechanism at its insertion. Clinically, this was manifested by a flexion deformity of the DIP joint. Although the deformity was passively correctable in this patient, the injury required stabilization to restore the extensor mechanism and prevent persistent extensor lag. The simultaneous occurrence of a PIP fracture-dislocation

and a mallet fracture therefore presented a complex injury pattern involving two adjacent joints and both flexor-extensor functional units of the finger.

The primary objective of treatment in PIP fracture-dislocations is to achieve stable reduction while allowing early controlled motion. This is essential because the ultimate functional outcome of these injuries depends not only on fracture union but also on preservation of joint motion. Conventional treatment options include closed reduction and splinting, extension-block splinting, percutaneous pinning, open reduction and internal fixation, volar plate arthroplasty, hemi-hamate reconstruction, and dynamic external fixation. The choice depends on fracture morphology, percentage of articular involvement, joint stability, comminution, and the ability to obtain and maintain a congruent reduction.

In the present case, a dynamic external fixator based on the Suzuki frame technique was selected for management of the PIP fracture-dislocation. Dynamic external fixation is particularly useful in unstable intra-articular fracture-dislocations because it provides continuous traction across the injured joint while permitting early active and passive range of motion. The principle is to maintain reduction by distraction and ligamentotaxis while avoiding rigid immobilization of the PIP joint. The elastic traction mechanism permits controlled joint motion and helps maintain alignment during the healing period.

The surgical construct used in this patient consisted of an axial traction K-wire placed through the center of rotation of the proximal phalangeal head, a hook K-wire through the middle phalanx, and an additional reduction K-wire placed close to the fracture site. The elastic band connecting the traction and hook pins provided continuous dynamic traction across the PIP joint. This configuration allowed the fracture fragments to remain aligned while simultaneously permitting controlled PIP motion. The additional reduction pin was particularly useful for correcting the dorsal displacement and maintaining reduction under fluoroscopic guidance.

An important advantage of the Suzuki frame is that it converts the treatment from static immobilization to dynamic stabilization. Continuous traction reduces the tendency of the middle phalangeal base fragment to displace dorsally, while the preserved arc of motion reduces the development of adhesions and capsular contracture. Early controlled movement also facilitates tendon gliding and helps maintain functional excursion of the flexor and extensor mechanisms. These principles are especially important for the index finger, where preservation of fine motion is essential for pinch, grasp, and dexterity.

In this patient, controlled PIP joint mobilization was initiated immediately after surgery. This approach was chosen to minimize stiffness while maintaining fracture reduction. The elastic band tension was adjusted during follow-up according to the stability and clinical progress of the fracture. The frame was retained for six weeks, by which time satisfactory progression of fracture union and maintenance of joint alignment were observed. There was no evidence of pin-tract infection or loss of reduction. These findings demonstrate the practical advantage of dynamic external fixation in maintaining stability during the healing period without sacrificing early joint movement.

The management of the associated mallet fracture was performed separately by closed reduction and percutaneous fixation using a 1.0-mm K-wire. Stabilization of the bony mallet fragment restored the distal extensor mechanism and maintained the DIP joint in an appropriate position during fracture healing. The K-wire was retained for eight weeks and subsequently removed. At three months, the patient had no residual DIP extensor lag, indicating satisfactory restoration of the terminal extensor mechanism. The absence of persistent mallet deformity is particularly important because even a small residual extensor lag may interfere with finger function and may become symptomatic during gripping activities.

One of the major complications following PIP fracture-dislocation is postoperative stiffness. Although the patient achieved maintained fracture reduction and satisfactory union, PIP flexion was initially limited to approximately 90° at six weeks. This stiffness is not unexpected following a significant intra-articular injury and temporary external fixation. Importantly, the limitation gradually improved with physiotherapy. By three months, PIP flexion had improved beyond 90°, and the patient regained a full functional grip. This improvement supports the importance of early mobilization and structured hand physiotherapy in the management of PIP fracture-dislocations.

The absence of infection in this patient is also noteworthy. Dynamic external fixation involves percutaneous K-wires and therefore carries a potential risk of pin-tract infection. Regular pin-site care, appropriate dressing, and close follow-up are essential to minimize this complication. In the present case, daily pin-site care was performed and no clinically significant pin-tract infection occurred. Proper patient education and surveillance are therefore important components of treatment when using external fixation.

Compared with open reduction and internal fixation, dynamic external fixation avoids extensive surgical exposure of the PIP joint and minimizes additional disruption of the already injured soft tissues. This may be particularly beneficial in comminuted intra-articular fractures, where obtaining stable fixation with screws or plates can be technically difficult. Open procedures may also increase the risk of postoperative stiffness because of soft-tissue dissection and scarring. Dynamic external fixation, in contrast, relies on indirect reduction, ligamentotaxis, and controlled distraction.

However, dynamic external fixation is not without limitations. Accurate placement of the wires is technically demanding, and improper positioning may interfere with the center of rotation of the PIP joint or produce malalignment. Excessive distraction can also adversely affect joint mechanics. Pin-site infection, wire loosening, skin irritation, and patient discomfort are potential complications. Successful treatment therefore depends on careful surgical technique, appropriate frame assembly, regular monitoring, and supervised rehabilitation.

The present case also highlights the importance of addressing both injuries simultaneously rather than focusing on the more obvious PIP fracture-dislocation alone. Failure to recognize and stabilize the associated mallet fracture may result in persistent DIP extensor lag despite successful treatment of the PIP injury. Conversely, prolonged immobilization of the entire finger to treat both injuries could increase the risk of severe PIP stiffness. The treatment strategy used in this case allowed independent stabilization of the mallet fracture while maintaining dynamic motion at the PIP joint.

The functional outcome in this patient was favorable. At three months, the patient had more than 90° of PIP flexion, no residual DIP extensor lag, full functional grip, and no pain or instability. He was able to perform routine daily activities without significant limitation. Although radiographic union is an important endpoint, functional recovery is particularly relevant in hand injuries. The outcome in this case demonstrates that restoration of a stable and congruent joint combined with early mobilization can provide satisfactory functional recovery even in a complex combined injury.

Overall, this case emphasizes that dynamic external fixation using the Suzuki frame is a useful joint-preserving option for unstable PIP fracture-dislocations, particularly when early motion is desirable. When associated with a bony mallet injury, simultaneous percutaneous stabilization of the distal phalanx fracture allows restoration of DIP extensor function while avoiding unnecessary immobilization of the PIP joint. The favorable clinical outcome in this case suggests that careful fracture reduction, dynamic traction, early controlled mobilization, appropriate pin-site care, and structured physiotherapy can achieve fracture union with preservation of useful finger function.

Nevertheless, as this is a single case, the results cannot be generalized to all combined PIP fracture-dislocations and mallet injuries. Larger clinical series with standardized functional outcome measures and longer follow-up would be required to determine the reproducibility of this treatment strategy and its long-term effect on PIP joint motion, grip strength, pain, and post-traumatic arthritis.

CONCLUSION

Combined mallet fracture and middle phalanx base fracture-dislocation injuries are uncommon These complex injuries can result in significant deformity and disability if not addressed immediately. A hybrid fixation strategy using closed K-wire fixation of the mallet fracture and Suzuki frame dynamic external fixation for PIP joint injury offers stable reduction, preservation of joint congruity, and early mobilization. This technique can achieve good functional outcomes in patients.

Clinical Message

Suzuki frame dynamic external fixation combined with closed pinning is a reliable and reproducible treatment option for complex phalangeal injuries involving simultaneous DIP and PIP joint pathology. Early mobilization following stable fixation is critical for achieving optimal functional outcomes.

Patient Consent

The authors certify that informed written consent was obtained from the patient for publication of clinical information and radiographic images. The patient understands that efforts will be made to conceal identity, although anonymity cannot be guaranteed.

Conflict of Interest

The authors declare no conflict of interest.

Funding

No funding was received for this study.

Learning Point of the Article

The coexistence of a bony mallet fracture and a proximal interphalangeal (PIP) joint fracture-dislocation in the same finger represents an uncommon and challenging injury pattern. A hybrid fixation strategy using K-wire fixation for the mallet injury combined with dynamic external fixation of the PIP joint provides stable reduction, maintains joint congruity, and permits early mobilization, resulting in excellent functional outcomes

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