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Research Article

A Dynamic Approach to Managing Unstable Proximal Interphalangeal Joint Fractures: The Suzuki Frame

Rasiq Rashid*, Imtiyaz Ahmad Beigh

Orthopedics, Department of Orthopedics, SKIMS MCH, Srinagar, Jammu and Kashmir, India

*Corresponding author: Rasiq Rashid; Department of Orthopedics, SKIMS MCH, Srinagar, Jammu and Kashmir, India. Tel: +91-7006050122; Email: drrasiq@gmail.com

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Abstract

Background: This study aimed to investigate the clinical and radiological outcomes in unstable proximal interphalangeal joint (PIPJ) fracture-dislocations using the Suzuki frame.
Methods: 21 patients (mean age: 33.14 years) with unstable fractures of the PIPJ were treated with a Suzuki frame. The mean interval between injury and surgery was 6.14 days. Early active range of motion (ROM) of all fingers was encouraged immediately after surgery. Patients were followed closely for the first two weeks, and clinical and radiological outcomes were measured at the final follow-up.
Results: Frames were removed at 6 weeks, with all fractures achieving union and stable, congruent PIPJ. One patient developed a pin-tract infection, resolved with antibiotics. Mean PIPJ ROM was -7.85° extension to 75.7° flexion; distal interphalangeal joint (DIPJ) ROM was -8.5° extension to 40.0° flexion. Mean grip strength was 13.5 kg, and mean visual analogue scale (VAS) pain score was 0.6. Early surgery (< 7 days) was associated with better DIPJ flexion (P = 0.008) and lower pain scores (P = 0.029).
Conclusion: The Suzuki frame is a convenient, inexpensive, and effective system to manage difficult unstable PIPJ fracture-dislocations.

Keywords: Kirschner Wire; Fracture Fixation; Joint Dislocations; Range of Motion

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Background

Proximal interphalangeal joint (PIPJ) fracture-dislocations are often missed in the emergency room due to their deceptively benign presentation (1). Proper anteroposterior (AP) and lateral radiographs are typically sufficient for diagnosis (Figure 1).

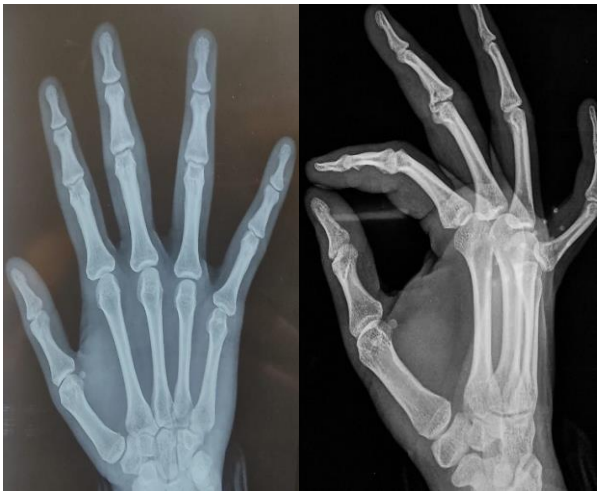

Figure 1. Anteroposterior (AP) and lateral radiographs showing proximal interphalangeal (PIP) fracture-dislocation (dorsal) of right middle finger in a 22-year-old man

If untreated, these injuries can lead to persistent pain and stiffness, causing significant disability. PIPJ injuries frequently involve damage to the volar plate, collateral ligaments, and the central slip of the extensor tendon, contributing to instability (2) (Figure 2).

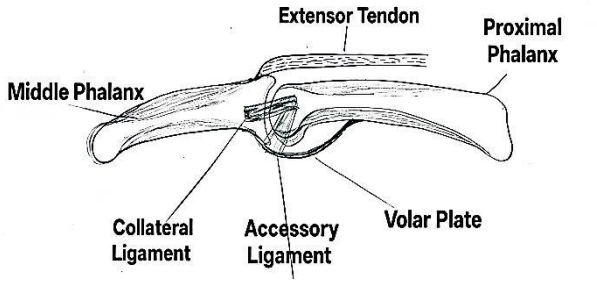

Figure 2. Stabilizers of proximal interphalangeal joint (PIPJ)

The mechanism of injury is usually an axial load applied to a slightly flexed joint. Kiefhaber and Stern classified these injuries based on stability (3). Volar lip fractures resulting in dorsal fracture-dislocation are the most common pattern (Figure 3).

Caggiano et al. proposed a treatment protocol emphasizing joint stability, articular congruity, and early mobilization of PIPJ injuries (1). Stable injuries can be managed non-operatively, while unstable injuries usually require surgery. Closed reduction via capsule-ligamentotaxis forms the basis of many dynamic external fixation systems, including the one described by Suzuki et al. (4). This study evaluates the clinical and radiological outcomes of the Suzuki frame in managing unstable PIPJ fracture-dislocations, addressing the need for validated, cost-effective treatment options.

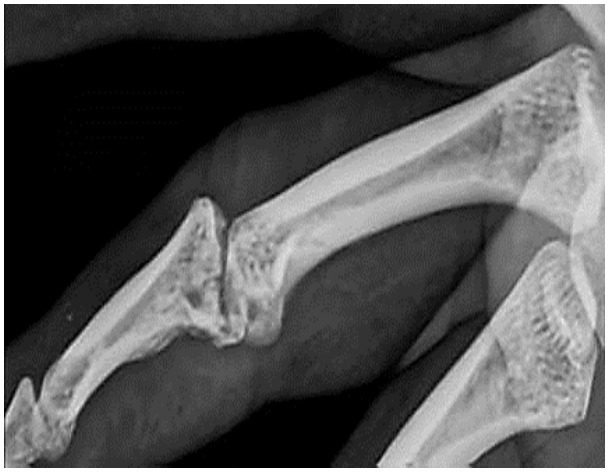

Figure 3. Volar lip fracture of proximal interphalangeal joint (PIPJ)

Methods

This prospective study was conducted at a tertiary care hospital on 21 patients with unstable PIPJ fracture-dislocations from February 2021 to October 2022.

Inclusion required informed consent. Patients were followed until April 2024.

Inclusion criteria were:

- Age > 18 years
- Closed PIPJ injuries
- Intra-articular fractures.

Exclusion criteria were:

- Age < 18 years
- Diabetes, rheumatoid arthritis (RA)
- Open injuries
- Extra-articular fractures.

On presentation, patients were evaluated for soft tissue swelling, vascularity, and deformity. AP and lateral radiographs confirmed the diagnosis. Closed reduction was attempted under digital anaesthetic block. Cases with instability were treated surgically. The mean surgical duration was 40 minutes.

Demographics and Injury Details (Table 1)

- ***Patients:*** 18 men, 3 women (mean age: 33.14 years, range: 18-62 years)
- ***Dominance:*** All right-hand dominant
- ***Injured Hands:*** Right (17 cases), left (4 cases)
- ***Injury Mechanisms:*** Sports-related (11 cases), falls (6 cases), work-related (4 cases)
- ***Time to Surgery:*** Mean: 6.14 days (range: 2-16 days)

Fracture Sites: Index finger (8 cases), long finger (7 cases), ring finger (4 cases), little finger (2 cases)

Surgical Technique

Modifications to Suzuki's Original Technique

- ***Axial Traction Pin:*** A 1.2-mm Kirschner wire (K-wire) was inserted transversely through the proximal phalanx, bent to form hooks.
- ***Hook Pin:*** A 1.0-mm K-wire was inserted transversely through the middle phalanx, bent to form hooks opposite to the axial pin.
- ***Reduction Wire:*** A 1.0-mm K-wire was placed to counteract dislocation, converting rubber band contraction into axial traction and compression forces (Figure 4).

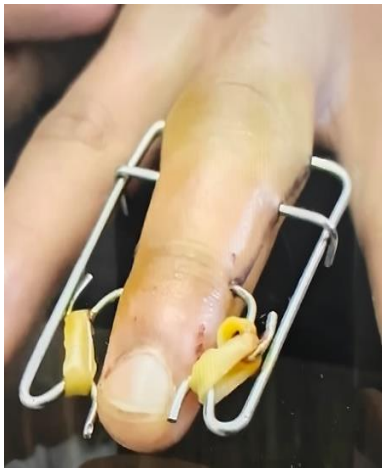

Figure 4. Intra-operative pictures of frame

Adequate reduction was confirmed intraoperatively using fluoroscopy in both the AP and lateral views (Figure 5a).

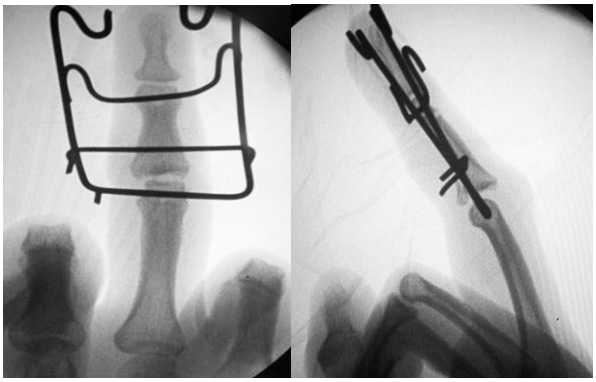

Figure 5a. Intraoperative C-arm images; Anteroposterior (AP) and Lateral, showing the application of Suzuki frame and fracture stabilization

Standard postoperative radiographs were obtained in all patients to evaluate reduction and fixation (Figure 5b).

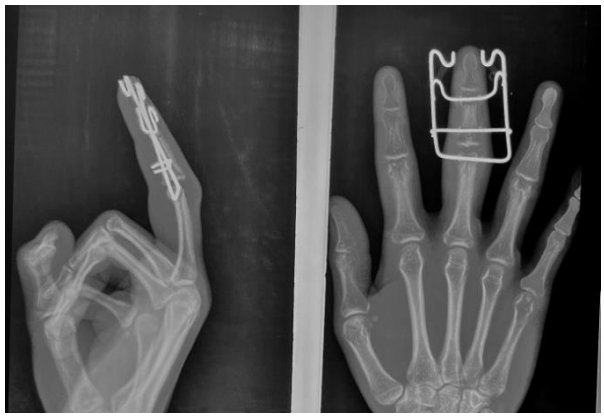

Figure 5b. Immediate post-operative anteroposterior (AP) and lateral radiographs demonstrating good reduction of fracture and congruent proximal interphalangeal joint (PIPJ)

Postoperative Protocol: Patients began active and passive exercises immediately. Pin-site care was demonstrated. Follow-ups occurred at 1 and 2 weeks. Frames were removed at 6 weeks after radiographic confirmation of union (Figure 6a).

Table 1. Demographics, injury details, and outcomes of the case series

Age (year)	Sex	Injury type	Side/finger involved	Mechanism of injury	Injury to surgery time (day)	ROM at PIPJ (extension/flexion)	ROM at DIPJ	Grip strength (kg)	VAS
35	Man	Dorsal	Right, middle finger	Work	2	0/70	-5/40	12.2	1
19	Man	Dorsal	Right, middle finger	Fall	5	-5/75	-10/45	15.0	0
24	Woman	Volar	Right, ring finger	Sports	3	-10/85	-10/45	16.0	0
26	Man	Pilon	Left, middle finger	Sports	7	-15/80	-10/35	14.6	1
62	Man	Dorsal	Right, middle finger	Fall	16	0/60	-10/30	10.5	2
48	Man	Dorsal	Right, index finger	Work	6	-10/75	0/40	11.0	0
18	Woman	Pilon	Left, ring finger	Sports	4	-15/85	-15/45	15.0	0

ROM: Range of motion; VAS: Visual analogue scale; PIPJ: Proximal interphalangeal joint; DIPJ: Distal interphalangeal joint

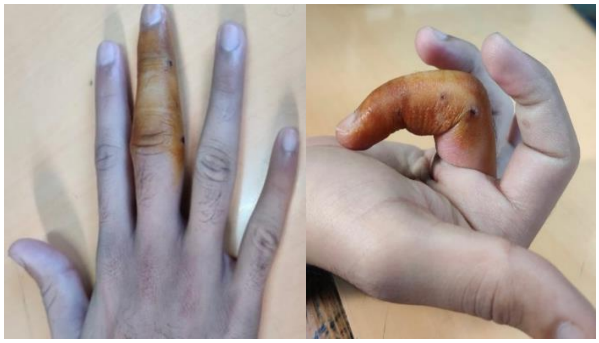

Figure 6a. Clinical pictures showing range of motion (ROM) at 6 weeks in injured middle finger

Results

The study included 21 patients (18 men and 3 women) with a mean age of 33.14 years [95% confidence interval (CI): 28.5-37.8, range: 18-62]. All cases were operated on in a closed manner, preserving the fracture biology. The anatomical union was obtained in all patients (Figure 6b).

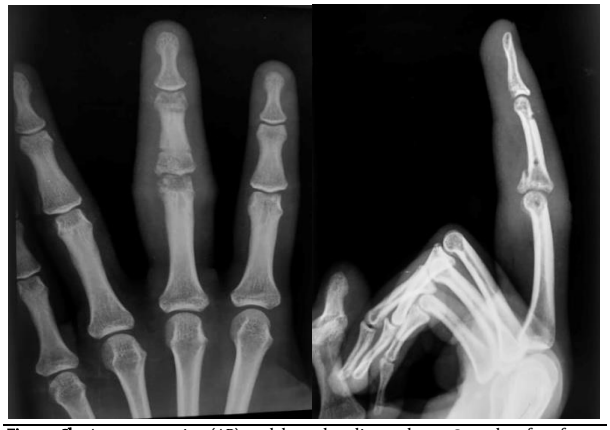

Figure 6b. Anteroposterior (AP) and lateral radiographs at 6 weeks after frame removal showing fracture union and stable and congruent proximal interphalangeal joint (PIPJ) of injured middle finger

All patients had a congruent and stable PIPJ. Suzuki frames were removed in all cases at 6 weeks.

All cases involved unstable PIPJ injuries, with 16 patients presenting within a week of injury and 5 patients presenting after 2 weeks. Injuries were distributed across the middle, ring, and index fingers, and mechanisms of injury included sports-related trauma (11 cases, 52%), falls (6 cases, 29%), and work-related accidents (4 cases, 19%).

The mean follow-up duration was 10.2 months (95% CI: 8.9-11.5). All fractures healed within acceptable alignment and stability, with no cases of persistent joint instability. One patient developed a pin-tract infection that resolved with a short course of oral second-generation cephalosporins.

The mean PIPJ active range of motion (ROM) was -7.9° extension (95% CI: -10.2 to -5.5) to 75.7° flexion (95% CI: 71.9-79.4). The mean distal interphalangeal joint (DIPJ) active ROM was -8.5° extension (95% CI: -10.8 to -6.2) to 40.0° flexion (95% CI: 36.3-43.7) (Figure 7a, b). The average grip strength was 13.5 kg (95% CI: 12.3-14.7, range: 10.5-16.0 kg). The mean visual analogue scale (VAS) pain score was 0.57 (95% CI: 0.3-0.9, range: 0-2).

Patients were divided into two groups based on the time between injury and surgery: early surgery (< 7 days) and delayed surgery (≥7 days). Statistical comparisons revealed the following:

DIPJ Flexion: Patients undergoing early surgery had significantly better flexion (mean = 43.8°, 95% CI: 39.4-48.1) compared to those with delayed surgery (mean = 32.5°, 95% CI: 28.3-36.7, P = 0.008).

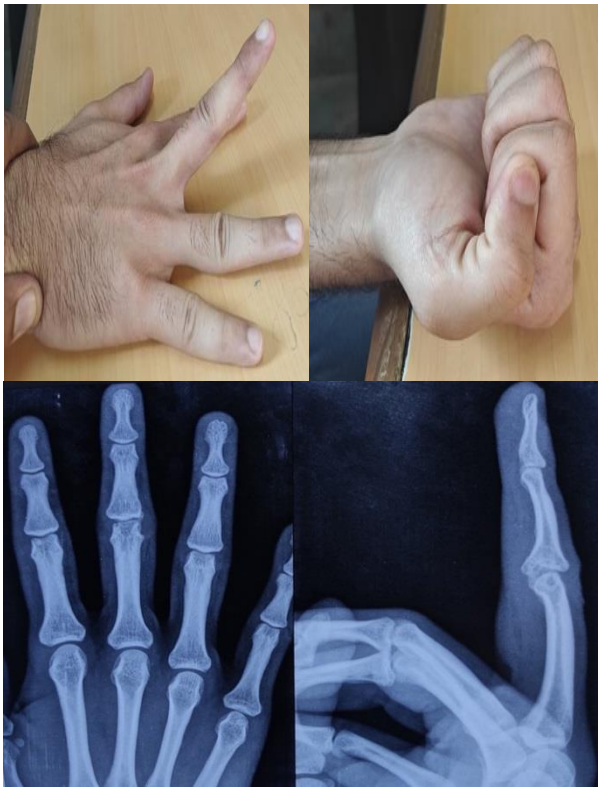

Figure 7. a) Clinical pictures showing range of motion (ROM) at 9 months in injured middle finger; b) Anteroposterior (AP) and lateral radiographs at 9 months after frame removal showing fracture union and stable and congruent proximal interphalangeal joint (PIPJ) of injured middle finger

- VAS (Pain): Early surgery was associated with significantly lower pain scores (mean = 0.33, 95% CI: 0.1-0.6) compared to delayed surgery (mean = 1.5, 95% CI: 1.1-1.9, P = 0.029).
- Grip Strength: Early surgery resulted in higher grip strength (mean = 14.8 kg, 95% CI: 13.5-16.1) compared to

delayed surgery (mean = 11.8 kg, 95% CI: 10.4-13.2), although this difference did not reach statistical significance (P = 0.533). However, a trend toward improved strength in early surgery patients was observed.

- PIPJ Flexion and Other Metrics: No significant differences were observed between the groups for PIPJ flexion.

The results suggest that early intervention (< 7 days) with the Suzuki frame significantly improves DIPJ flexion, reduces pain levels, and shows a trend toward better grip strength, highlighting the importance of timely surgical management in unstable PIPJ fracture-dislocations.

Discussion

PIPJ fracture-dislocations require immediate recognition and stabilization due to their propensity to cause long-term morbidity if untreated. Missed diagnoses often result in late presentations with finger stiffness and pain. Dynamic external fixation, such as the Suzuki frame, has emerged as the preferred approach for unstable PIPJ injuries, as highlighted by Gianakos et al. in a systematic review (2). This method enables joint stabilization while allowing early mobilization, minimizing stiffness, and improving functional outcomes.

Suzuki's pins and rubber traction system, introduced for managing complex PIPJ injuries, offers several advantages. It is minimally invasive and cost-effective, and dynamically restores joint alignment. Suzuki et al. demonstrated its effectiveness in four cases, achieving an average ROM of 80° (4). Subsequent studies have further validated these findings. Deshmukh et al., in their study of 13 patients, reported that 92% returned to their occupational activities, with no radiological evidence of osteolysis or clinical osteomyelitis (5).

Similarly, Slade et al. evaluated 8 patients using this system, observing an average PIPJ ROM from 1° to 89°, with grip strength at 92% of the unaffected hand (6). De Smet and Boone, in a series of 8 cases, documented near-normal function in half of the patients, with an average active ROM of 82° (7).

Additionally, Kiefhaber and Stern reviewed various treatments for PIPJ fracture-dislocations and emphasized the importance of achieving articular congruity and stability for optimal functional recovery (3).

Previous literature has consistently demonstrated the advantages of dynamic external fixation in managing PIPJ fracture-dislocations, particularly regarding maintenance of joint alignment while permitting early mobilization. Ruland et al. reported successful outcomes using distraction external fixation with mean PIPJ ROM improving to 89°, highlighting its biomechanical advantage in restoring articular congruity and reducing stiffness (8). More recently, Wang et al. introduced a modified distraction external fixator, demonstrating comparable results with enhanced construct simplicity and favourable clinical outcomes (9). A 2025 comparative analysis further confirmed that dynamic fixation provides superior joint motion and lower complication rates compared to static external fixation or internal fixation techniques, emphasising the importance of early mobilization in preserving function (10).

Our study corroborates these findings, demonstrating comparable functional outcomes. Early intervention was associated with significantly better DIPJ flexion, lower pain scores, and a trend toward improved grip strength, underscoring the importance of timely surgical management. Future research with larger sample sizes and long-term follow-ups could further refine treatment protocols and identify patient-specific factors influencing outcomes.

Conclusion

The Suzuki frame is a convenient and effective system for managing PIPJ fracture-dislocations, promoting fracture union and functional recovery. Early surgical intervention (< 7 days) enhances DIPJ flexion, reduces pain, and may improve grip strength. While our findings are promising, larger long-term studies are needed to confirm these results and refine treatment strategies.

Conflict of Interest

The authors declare no conflict of interest in this study.

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