

DYNAMIC EXTERNAL FIXATION USING SUZUKI FRAME FOR PROXIMAL INTERPHALANGEAL JOINT FRACTURE-DISLOCATIONS: A CASE SERIES

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ABSTRACT:

Background: Fracture-dislocations of the proximal interphalangeal (PIP) joint represent highly challenging hand injuries. If suboptimally managed, routinely culminate in chronic pain, severe joint stiffness, and long-term functional impairment. By utilizing the principles of ligamentotaxis, dynamic Suzuki frame external fixator maintains a stable reduction without sacrificing early joint mobility.

Aim: To evaluate the clinical, functional, and radiological outcomes of patients with proximal interphalangeal joint fracture-dislocations treated with Suzuki frame dynamic external fixation.

Materials and Methods: This prospective case series included 15 patients with unstable PIP joint fracture-dislocations treated using a Suzuki dynamic external fixator. Patients with pathological fractures or severe soft-tissue injuries were excluded. After closed or limited open reduction under C-arm guidance, the frame was applied using Kirschner wires and elastic bands to provide dynamic distraction and stability. Early active mobilization was initiated postoperatively. Clinical and radiological follow-up assessed union, range of motion, pain, and complications.

Results: The mean ROM at the PIP joint at the final follow-up was 81.5 +/- 11.8 (range: 55–100) degrees. The mean flexion at the PIP joint at the final follow-up was 83.4 +/- 9.5 degrees and the mean extension at the PIP joint was -1.9 +/- 3.8 degrees. No case of non-union was observed in the present study. Pin tract infection occurred in 20.0% of cases (3 patients) and was the most common complication observed. One patient (6.67%) needed realignment of K-wires for pin displacement. One patient (6.67%) developed wire breakage. The same patient also developed complex regional pain syndrome (CRPS) at two months. One patient (6.67%) developed painful arthritis of the PIP joint.

Conclusion: Suzuki's pin and rubber traction method is an effective modality of treatment for intra-articular fractures of the base of the proximal phalanx of fingers of the hand. Although not free of complications, the final results in most patients are good.

KEYWORDS: Phalanx fracture, Suzuki frame, Pin and rubber traction

INTRODUCTION

Fracture-dislocations of the proximal interphalangeal (PIP) joint represent highly challenging hand injuries. If suboptimally managed, routinely culminate in chronic pain, severe joint stiffness, and long-term functional impairment. By utilizing the principles of ligamentotaxis, dynamic external fixation with a Suzuki frame maintains a stable reduction without sacrificing early joint mobility.

Traditional open reduction combined with internal fixation (ORIF) demands expansive soft-tissue disassembly. This approach introduces a heightened risk of devitalizing small, fragmented bone portions and necessitates prolonged postoperative immobilization—a common pathway to permanent joint arthrofibrosis and severe stiffening. To navigate around these complications, Suzuki et al. introduced a dynamic external framework utilizing Kirschner wires and elastic rubber bands. This technique relies on the mechanical principle of continuous ligamentotaxis to maintain fracture alignment and joint distraction. Crucially, it allows for immediate, active mobilization during the bone-healing phase.

The objective of this prospective clinical series is to outline the functional performance, range of motion recovery, and complication profile observed when using the Suzuki frame to treat a cohort of 15 patients experiencing articular middle phalanx base fractures.

MATERIALS AND METHODS:

This prospective case series evaluated 15 patients with unstable PIP joint fracture-dislocations managed with a Suzuki dynamic external fixator at our tertiary care institution. To ensure a homogenous cohort, we excluded individuals presenting with pathological fractures, as well as those with severe, concomitant soft-tissue compromise.

Inclusion Criteria

1. Patients aged 18 years or older.
2. Acute PIP joint fracture-dislocations of the fingers.
3. Unstable dorsal, volar, or pilon fracture-dislocations requiring surgical stabilization.
4. Fractures involving >30–40% of the articular surface with joint instability.
5. Injury presentation within 3–4 weeks of trauma.
6. Closed fractures or Gustilo-Anderson Grade I open fractures.
7. Patients willing to comply with postoperative rehabilitation and follow-up.

Exclusion Criteria

1. Chronic or neglected injuries (>4 weeks old).
2. Skeletally immature patients.
3. Stable fracture-dislocations amenable to conservative treatment.
4. Associated tendon injuries requiring repair.
5. Severe soft-tissue loss or contaminated open fractures (Grade II/III).
6. Pathological fractures.
7. Previous deformity, arthritis, or stiffness of the involved PIP joint.
8. Multiple injuries preventing early mobilization of the finger.
9. Neurovascular injuries of the affected digit.
10. Patients unwilling or unable to complete follow-up.

Pre-operative Optimization

Patients entered the study through emergency triage or outpatient orthopedic clinics. Standard radiological profiles, including distinct anteroposterior (AP) and lateral views of the affected digit, were universally acquired. Initial stabilizing measures consisted of structural splinting, adjacent buddy-taping, and standardized oral or intravenous pain management.⁴ Comprehensive written informed consent from each participant were established before any surgical intervention.

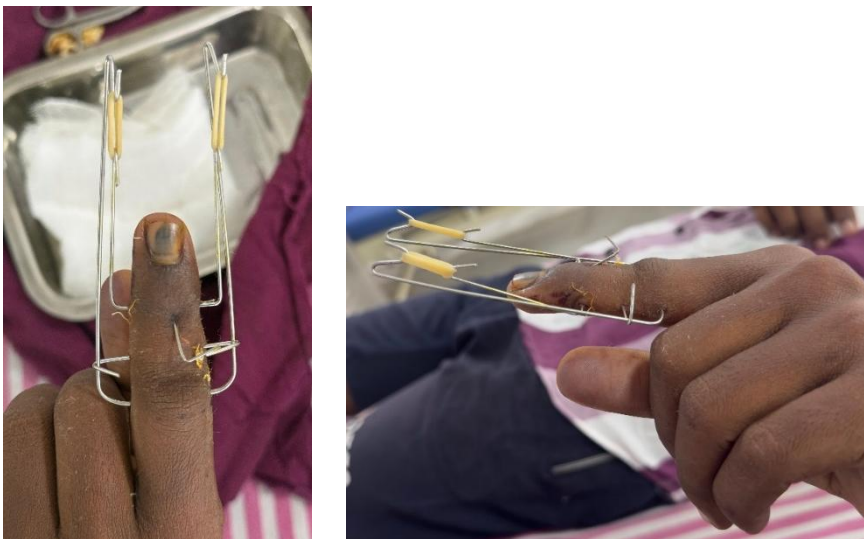
Surgical Technique

Every procedure was completed under regional anesthesia blocks. Prophylactically, a single 1.5 g dose of cefuroxime was administered half an hour prior to the initial pin placement. Fracture reduction was achieved using closed techniques driven by sustained longitudinal traction (ligamentotaxis).

The dynamic external framework was then constructed using a combination of three K-wires and calibrated rubber elastics.² First, an axial traction pin (1.2 mm K-wire) was driven transversely across the condylar head of the proximal phalanx, positioned just proximal to the PIP joint axis. Both exterior ends of this wire were bent at 90 degrees distally, terminating in custom-fashioned hooks. Second, a thinner hook pin (1.2 mm K-wire) was drilled horizontally through the neck/head region of the middle phalanx, with its external extensions similarly turned into receiving hooks. Finally, a reduction pin was placed immediately distal to the fracture site to correct residual volar or dorsal joint subluxation. Calibrated rubber elastics were stretched between the primary hooks to generate a continuous, distracting force across the joint line.²



Figure 1: Plain radiograph of the left hand- anteroposterior and oblique views- demonstrating displaced fracture at the base of second middle phalanx.



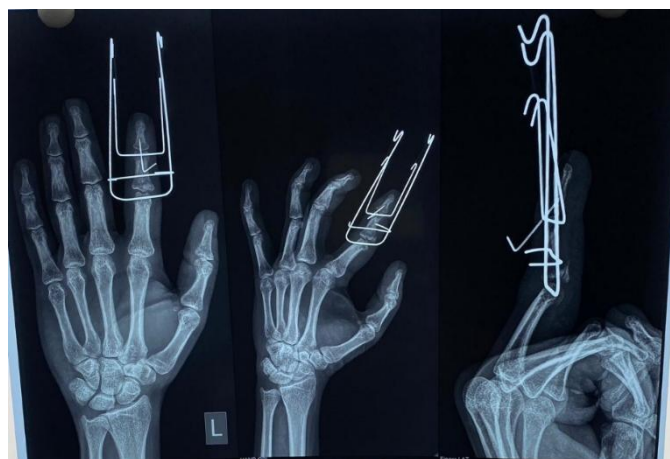


Fig 5: Post-operative follow up radiograph of left hand (AP, oblique & lateral views) following Suzuki frame fixation, showing maintained PIP joint alignment and satisfactory healing.



Fig 6 & 7: Follow up radiograph of the left hand (AP & oblique views) following removal of the Suzuki frame demonstrating maintained PIP joint alignment

Post-operative Care and Statistics

Active, self-directed range of motion exercises were initiated on post-operative day one. Patients were routinely discharged within 24 hours of the surgery and seamlessly transitioned to an outpatient hand physical therapy program. Clinical and radiographic reviews were maintained for a minimum follow-up duration of one year. Objective parameters, specifically PIP joint arc of motion and any adverse post-operative events, were tracked and documented. Quantitative variables were statistically managed using SPSS Version 20.0

Following either closed or limited open reduction under C arm guidance, the Suzuki frame was constructed and secured using Kirschner wires and elastic bands to establish optimal dynamic distraction and joint stability.^{2,5} Postoperatively, a supervised regimen of early active range-of-motion exercises was initiated immediately to counteract joint stiffness and facilitate functional recovery.⁶ Long-term monitoring consisted of sequential clinical and radiological follow-ups to track objective parameters, including time to fracture union, total arc of motion, residual pain scores, and any implant-related complications.³

RESULTS

A total of 15 patients with proximal interphalangeal (PIP) joint fracture-dislocations were managed using the Suzuki dynamic external fixation technique and completed the follow-up protocol. The study cohort comprised 11 males (73.3%) and 4 females (26.7%), with a mean age of 28.5 ± 8.9 years (range: 18–50 years), indicating a predominance of young, active individuals.

The most common mechanism of injury was sports-related trauma, accounting for 40.0% ($n = 6$) of cases, particularly during volleyball and cricket activities. This was followed by punch-related injuries, which constituted 33.3% ($n = 5$) of cases. The remaining injuries resulted from falls and other direct traumatic events to the hand.

The dominant hand was involved in 10 patients (66.7%), highlighting the increased vulnerability of the functionally active hand. Among the digits affected, the index finger was the most frequently injured (40.0%, $n = 6$), whereas the little finger was the least commonly involved (13.3%, $n = 2$).

Radiographic evaluation demonstrated that volar lip avulsion fractures associated with dorsal subluxation represented the predominant fracture pattern, accounting for 60.0% ($n = 9$) of cases. The remaining injuries included comminuted intra-articular fractures and pilon-type fracture-dislocations.

The mean duration between injury and definitive surgical intervention was 7.1 ± 3.8 days. The average operative time for application of the Suzuki frame was 30.5 ± 5.8 minutes, reflecting the relative simplicity and reproducibility of the technique.

At final follow-up, satisfactory fracture union and maintenance of joint congruity were achieved in the majority of patients. Early mobilization facilitated by dynamic external fixation contributed to functional recovery while minimizing prolonged joint stiffness.

Complications were observed in 7 patients (46.7%). The most common complication was superficial pin-site infection (20.0%, n = 3), which resolved with local wound care and dressings. Mechanical pin displacement (6.7%, n = 1) required K-wire realignment under local anesthesia. Wire breakage (6.7%, n = 1) was managed by replacement of the broken wire and frame adjustment. Complex Regional Pain Syndrome (CRPS) (6.7%, n = 1) responded to stellate ganglion block therapy, while severe post-traumatic arthritis (6.7%, n = 1) ultimately required secondary arthrodesis. Notably, 53.3% (n = 8) of patients experienced no complications during the study period

Overall, the Suzuki frame provided stable fixation through ligamentotaxis, enabled early active motion, and resulted in acceptable clinical and radiological outcomes in the treatment of unstable PIP joint fracture-dislocations.

Table 1: Baseline Demographic Features And Functional Outcomes (n = 15)

Variable	Category	Frequency (n)	Percentage (%) / Mean±Sd
Age (years)	Mean age	-	28.5 ± 8.9 (Range: 18–50)
Gender	Male	11	73.33
	Female	4	26.67
Injury mechanism	Sports injury	6	40.00
	Direct trauma	5	33.33
	RTA	4	26.67
Hand involved	Dominant hand	10	66.67
	Non-dominant hand	5	33.33
Digit involved	Index finger	6	40.00
	Ring finger	4	26.67
	Middle finger	3	20.00
	Little finger	2	13.33
Fracture pattern	Volar avulsion	9	60.00
	Dorsal avulsion	4	26.67
	Pilon fracture	2	13.33
Surgical parameters	Pre-operative delay (days)	-	7.1 ± 3.8
	Operative time (minutes)	-	30.5 ± 5.0
Functional Outcome	Mean final flexion at PIP joint	-	83.4 ± 9.5
	Mean final extension lag at PIP joint	-	1.9 ± 3.8
	Total PIP arc of motion	-	81.5 ± 11.8 (Range: 55–100)

Table 2: Complication Matrix And Resolution Schemes (n=15)

Documented Secondary Pathology	Patient Incidence (N, %)	Clinical Resolution Strategy
Superficial Pin-Site Infection	3 (20.00%)	Resolved using local antiseptic hygiene and serial dry dressings
Mechanical Pin Displacement	1 (6.67%)	Re-alignment of K-wires conducted under local anesthesia
Wire breakage	1 (6.67%)	Broken wire fragment removed under local anesthesia; the frame was reconstructed with a new K-wire and stability of fixation ensured
Complex Regional Pain (CRPS)	1 (6.67%)	Successfully resolved with a therapeutic stellate ganglion block

Documented Secondary Pathology	Patient Incidence (N, %)	Clinical Resolution Strategy
Severe Post-Traumatic Arthritis	1 (6.67%)	Treated via secondary surgical arthrodesis of the PIP joint

*CRPS: complex regional pain syndrome; PIP: proximal interphalangeal; SD: standard deviation.

Complication Distribution Following Suzuki Frame Application (n=15)

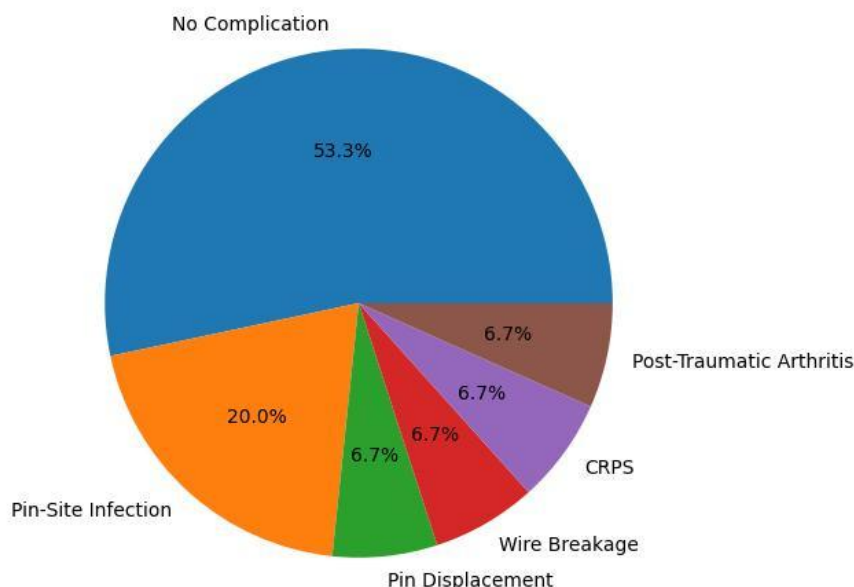


Figure 8: Distribution of Complications Following Dynamic External Fixation Using the Suzuki Frame

DISCUSSION

This prospective investigation demonstrates that young, active working-age adults represent the primary demographic sustaining intra-articular base fractures of the middle phalanx, as evidenced by our cohort's mean age of 28.5 years. The clear male predominance and high rate of injury to the dominant hand align with the physical demands associated with high-impact sports like volleyball and cricket, as well as direct trauma to the finger. In agreement with established hand trauma literature, volar plate avulsions accompanied by various degrees of joint subluxation constituted the most frequent fracture morphology.

From a technical standpoint, the Suzuki dynamic frame offers a straightforward and highly reproducible approach. This is highlighted by the short, consistent operative times across cases (30.5+/- 5.8 minutes), despite execution by different attending surgeons. A major advantage of the Suzuki dynamic external fixation system is that it permits immediate postoperative mobilization of the proximal interphalangeal (PIP) joint while maintaining fracture reduction through ligamentotaxis. Active range-of-motion exercises were initiated from the first postoperative day, minimizing periarticular adhesions and joint stiffness. The final functional recovery observed here (mean total PIP motion arc of 81.5 degrees) compares favorably with performance benchmarks set by other historical dynamic traction cohorts, such as those published by De Soras et al. (84 degrees) and Duteille et al. (85.9 degrees)⁸, while outperforming the historical averages noted by Majumdar et al. (74 degrees)⁹.

While our clinical outcomes were generally highly encouraging, the technique is not without risk. Pin-tract site contamination was the most common complication (20.0%), though it was easily managed with local wound care and regular dressing changes. For the single case of advanced, painful post-traumatic arthritis, converting to a stable PIP joint arthrodesis provided effective pain relief and structural recovery.

Importantly, despite minor residual loss of full motion arcs compared to an uninjured digit, all 15 patients successfully resumed their standard activities of daily living. This functional recovery is clinically significant, as the mean postoperative PIP joint arc of motion achieved in the present study exceeds the minimum range required for most activities of daily living.

Previous biomechanical studies have demonstrated that functional hand use can be maintained with substantially less than the full physiological range of PIP joint motion, supporting the clinical relevance of the outcomes observed in this series.

CONCLUSION

The Suzuki pin-and-rubber distraction framework remains an exceptionally reliable, effective, and minimally invasive option for treating intra-articular middle phalanx base fractures.^{2,7} It successfully prevents joint non-union and long-

term stiffness by prioritizing immediate joint mobilization under continuous distraction. While pin-related track complications require careful monitoring, overall functional recovery remains high. We recommend initiating multicenter, randomized controlled trials to systematically compare this framework against other modern internal fixation options.

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