

# Dynamic Intradigital External Fixation for Proximal Interphalangeal Joint Fracture Dislocations

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**Purpose:** Many skeletal traction devices have been described to treat fracture dislocations of the proximal interphalangeal (PIP) joint. Most of these techniques are technically challenging or involve cumbersome frames. We present a design modification that enhances the stability of a simple dynamic fixation system described previously and report our results with this technique.

**Methods:** A previously described simple dynamic fixator with no rubber bands was applied to 6 patients who sustained fracture dislocations of the PIP joint. The middle finger was involved in 3 patients, the ring finger in 1 patient, and the small finger in 2 patients. The average age of the patients was 27 years (range, 21–42 y). The average involvement of the base of the middle phalanx was 48% (range, 35% to 60%). The average time from the injury to the surgery was 6 days (range, 1–14 d). The average follow-up period was 24 months (range, 7–43 mo). Immediate active flexion extension was allowed and the fixator was removed after 3 to 4 weeks.

**Results:** The average range of motion of the PIP joint at the final follow-up evaluation was 5° to 89° (range, 0° to 100°). Two patients developed pin track infection that resolved with oral antibiotics. Only one patient complained of mild pain with extreme flexion. Proper reduction and congruency of the joint was noted on final anteroposterior and lateral radiographs.

**Conclusions:** A simple dynamic fixator for the treatment of unstable PIP joint fracture dislocations was used successfully in 6 digits to maintain reduction and restore digital range of motion. The addition of modifications to the original technique not only improves the solidity of the construct but also provides satisfactory functional results. Based on our experience we recommend this easy technique to treat fracture dislocations of the PIP joint. (*J Hand Surg* 2005;30A:154–160. Copyright © 2005 by the American Society for Surgery of the Hand.)

**Key words:** Proximal interphalangeal joint, fracture dislocation, dynamic fixation.

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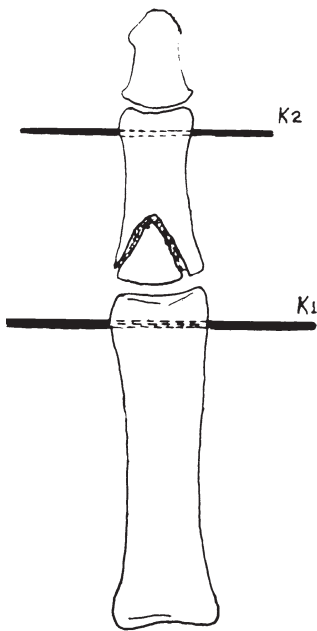
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Fracture dislocations of the proximal interphalangeal (PIP) joint are common injuries that can lead to stiffness, pain, and posttraumatic arthritis when treated improperly. Treatment of these lesions is even harder with delayed presentation, when they have been mistaken as a jammed finger. Lateral deviation and rotation of this joint are minimized by its characteristic bony architecture.<sup>1–5</sup> Soft-tissue stability is provided by the ulnar and radial collateral ligaments, volar plate, dorsal capsule, lateral bands, central tendon of the dorsal apparatus, and flexor



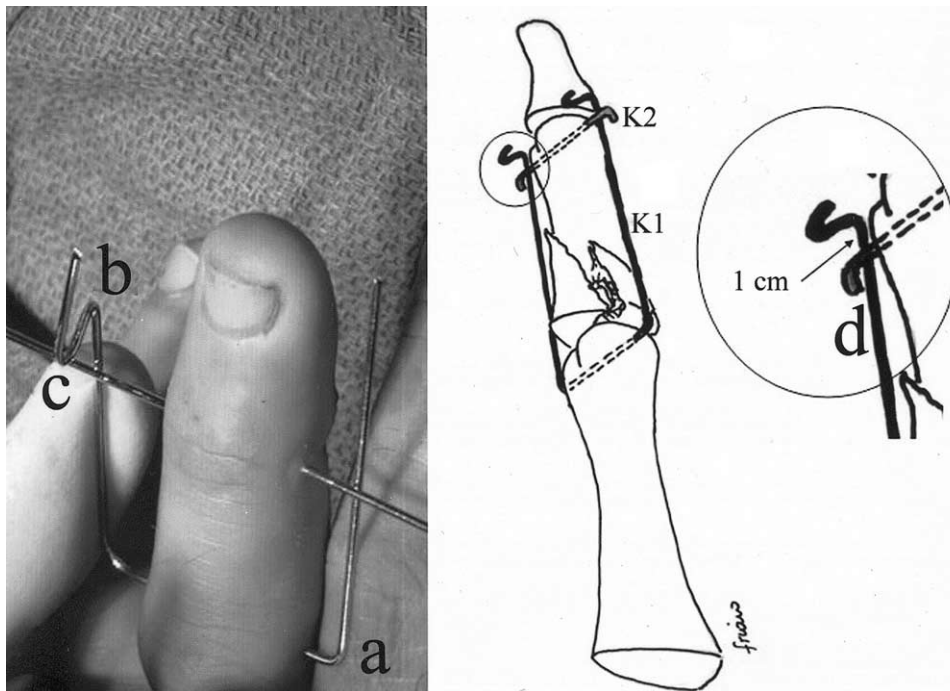
**Figure 1.** The first K-wire (K1) is placed transversely through the center of the head of the proximal phalanx. The second K-wire (K2) is driven through the head of the middle phalanx.

tendon sheath.<sup>4</sup> The typical mechanism of injury for dorsal fracture dislocations is a direct force applied to the fingertip with hyperextension and axial loading of the PIP joint that causes impaction of the volar ar-

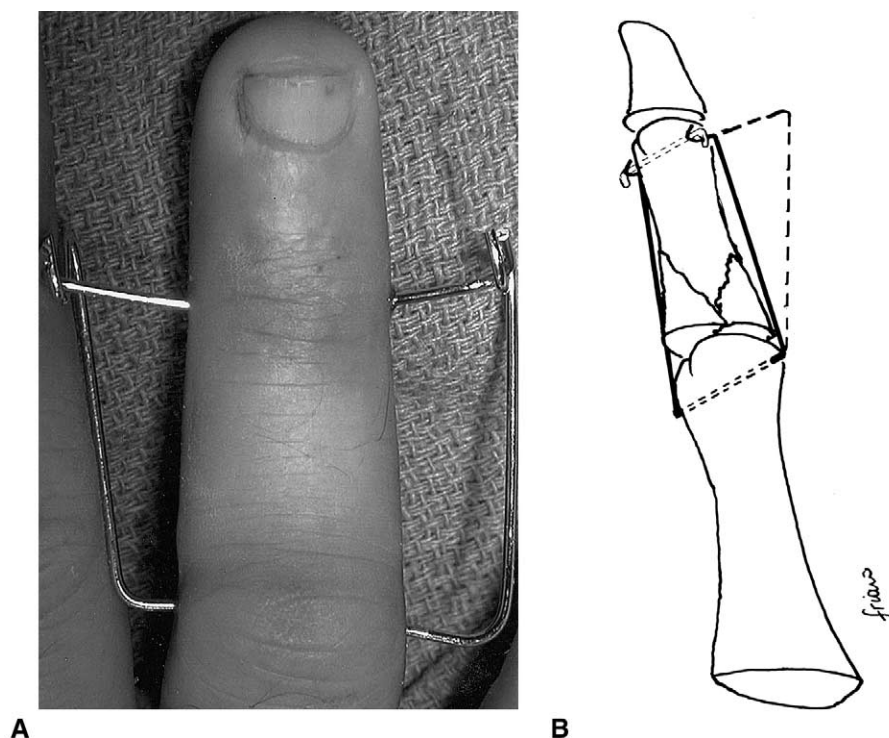
ticular lip of the middle phalanx against the condyles of the proximal phalanx.<sup>6,7</sup> Dorsal fracture dislocations are more common than volar ones<sup>1</sup> and often are seen in ball-handling athletes.<sup>8</sup>

Depending on the severity of the comminution and the stability of the PIP joint, treatment may be either nonsurgical or surgical. Involvement of the articular surface at the base of the middle phalanx is generally less than 40% in stable fractures and more than 40% in unstable injuries.<sup>3</sup> Surgical treatment is required in the presence of unstable fracture dislocations.<sup>3</sup> Fractures with significant comminution or fragment displacement also are indicated for surgical treatment.

Different surgical techniques have been used to treat fracture dislocations of the PIP joint: closed reduction and percutaneous fixation,<sup>9</sup> dorsal extension block pinning,<sup>10,11</sup> open reduction and internal fixation,<sup>4,9,12-14</sup> and traction-fixation.<sup>6,15-29</sup> Early motion of the PIP joint along with traction and stable fixation have provided the best functional results.<sup>18,21,27,29</sup> Gaul and Rosenberg<sup>29</sup> described a simple frame that provided traction without using rubber bands or complicated connecting pieces. We introduce a modification to the original frame described by Gaul and Rosenberg<sup>29</sup> and report our experience with the use of this simple intradigital



**Figure 2.** K1 is bent 90° forward to lie parallel to the middle phalanx (a). Two more bends are applied to K1: a dorsal bend (>90°) at the base of the distal phalanx (b) and another bend on each end of the pin (c). The ends of K2 also are bent to maintain proper engagement of K1 and to adjust the extent of distraction at the PIP joint (d).



**Figure 3.** (A) Traction is applied on the middle phalanx to engage K2 in the horns of K1. (B) The dotted line represents the direction of K1 in the original description by Gaul and Rosenberg<sup>29</sup> that had a longer lever arm compared with our modification. This can lead to loss of distraction force over time.

dynamic fixator that can be applied under a digital block and in the office setting.

### Methods

Six patients (4 men, 2 women) who sustained fracture dislocation of the PIP joint were treated with a dynamic external fixator between 1999 and 2002 by the senior author (A.B.). The average age was 27 years (range, 21–42 y). The middle finger was involved in 3 patients, the ring finger in 1 patient, and the small finger in 2 patients. The average follow-up period was 24 months (range, 7–43 mo). Fracture dislocation was caused by crushed injury on all patients and all the fractures were closed. The average involvement of the base of the middle phalanx was 48% (range, 35%–60%). Open reduction of a displaced pilon fragment was performed through a small midaxial incision in 2 patients. We did not need to use internal fixation to keep the fragment reduced once longitudinal traction was achieved with the frame in these 2 patients. The average time from the injury to the surgery was 6 days (range, 1–14 d).

### Surgical Technique

After administration of digital block anesthesia a 1.4-mm (0.045-in) K-wire (K1) is placed trans-

versely through the center of the head of the proximal phalanx while under fluoroscopic control. A second K-wire (K2) then is driven through the head of the middle phalanx (Fig. 1). The first wire (K1) is left long enough on both sides so the ends can be bent 90° distally to lie parallel and 1 cm away from the middle phalanx (Fig. 2). The main modification of the frame is shown in Figure 3 where the dotted line represents the volar direction of K1 in the original description by Gaul and Rosenberg,<sup>29</sup> which had a longer lever arm. This can lead to loss of distraction force overtime. The modification in the frame ensures a vector of longitudinal force parallel to the middle phalanx.

Two more bends are applied to the proximal phalanx wire: a dorsal bend (>90°) at the base of the distal phalanx and another bend on each end of the pin. The initial dorsal bend is approximately 1 cm distal to K2 (Fig. 2). Traction then is applied on the middle phalanx so it is engaged in the horns of the proximal phalanx K-wire, achieving the desired skeletal traction. As a further stabilizing modification the second pin ends also can be bent to maintain the engaged initial pin and used to adjust the extent of distraction at the PIP joint (Fig. 2). Intraoperative



**Figure 4.** (A) Sequence of intraoperative lateral x-rays of the PIP joint showing a complex intra-articular fracture pattern and loss of joint space. (B, C) Once the frame is applied, active flexion extension is encouraged to confirm satisfactory joint space and alignment throughout the entire range of motion with fluoroscopy.

x-rays are obtained at this point to evaluate the distraction at the joint space and to confirm that the articular surface of the base of the middle phalanx is not in contact with the condyles of the proximal phalanx. The extent of articular displacement then is assessed and open reduction may be necessary, particularly if impacted articular fragments remain displaced. Limited open reduction is performed to obtain tolerable congruency of the PIP joint via a midaxial approach when necessary. Once the reduction is obtained sedation is kept at a minimum to encourage active flexion and extension with the external fixator in place to confirm proper joint alignment with fluoroscopy (Fig. 4); the primary objective is to obtain an active range of PIP joint flexion extension even if some joint subluxation is present. The finger is placed in a soft minimally bulky dressing, incorporating the external fixator. The dressings are removed the next day and immediate active flexion extension of the PIP joint is supervised by the hand therapist. This fixation provides active longitudinal traction while preserving the joint space and allowing PIP joint motion. The fixator is removed after 3 to 4 weeks. Radiographic and clinical assessments (range of motion, analogue pain scale, deformity, and stability) are obtained at final follow-up evaluation.

## Results

The average range of motion of the PIP joint at final follow-up evaluation was 5° to 89° (range, 0° to 100°). The final distal interphalangeal range of motion was on average 2° to 80° (range, 0° to 90°). Two patients developed pin tract infection that resolved with oral antibiotics. Proper reduction and congruency of the joint was noted on final anteroposterior and lateral radiographs. Only 1 patient complained of mild pain with extreme flexion. At final evaluation no instability was observed in any of the PIP joints (Table 1).

## Case Report

A 21-year-old man suffered an intra-articular fracture dislocation of the PIP joint of the right small finger. Anteroposterior and lateral views after closed reduction are shown in Figure 5A. A dynamic external fixator without rubber bands was placed as described earlier (Fig. 5B) and he started immediate active motion. The frame was removed after 3 weeks and he continued hand therapy until full range of motion was restored. He was pleased with the function results and he experienced no pain or swelling over the PIP joint at final follow-up evaluation (at 29 mo). The final range of motion was 5° to 90° for the PIP and 0° to 75° for the distal interphalangeal joint (Fig. 5D).



**Table 1. Summary of Results**

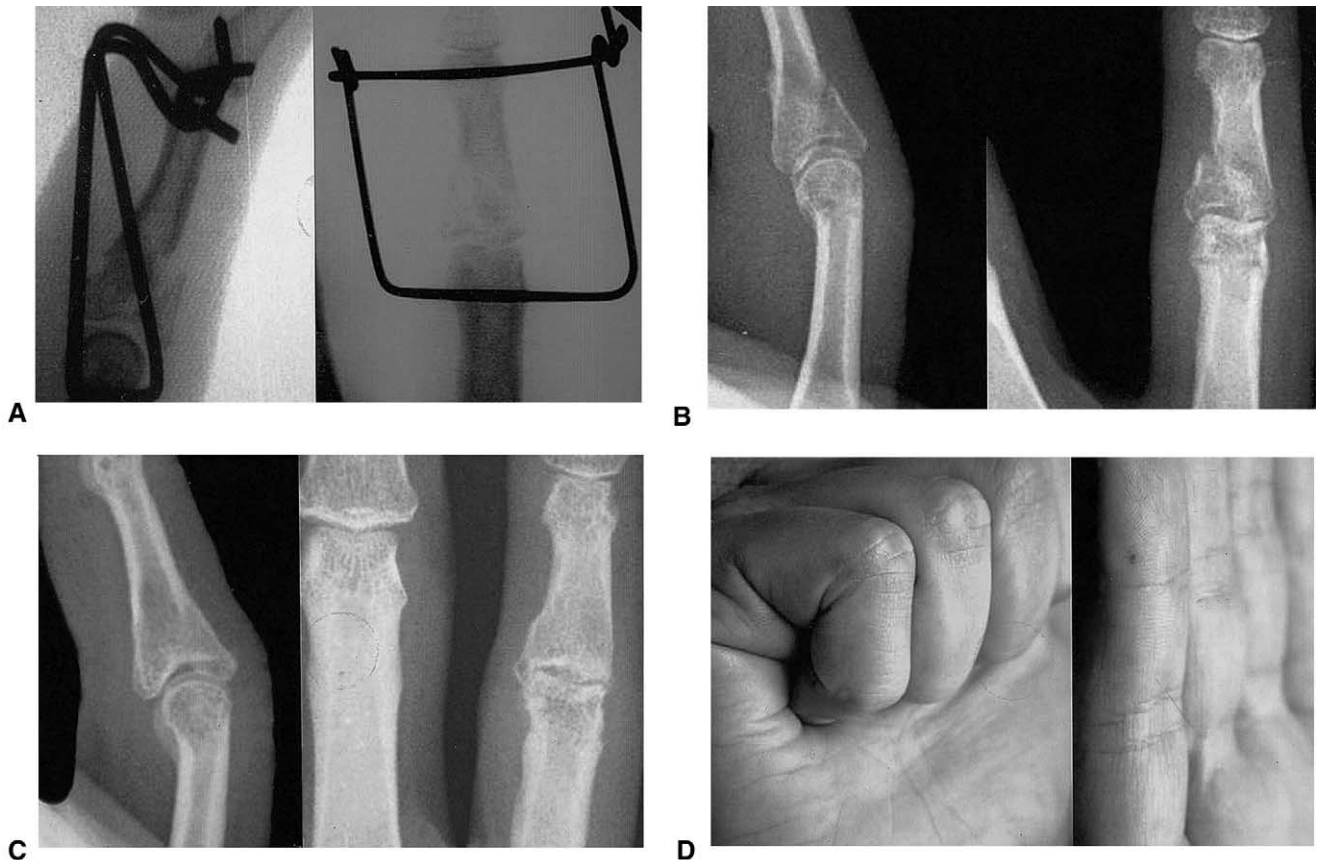
Patient	Gender/ Age	Delay (days)	Follow-Up (mo)	Percentage Base Middle Phalanx Fracture	Pain/Complications	PIP ROM (°)	DIP ROM (°)	Injured Finger
1	M/21	14	7	45	None	0–90	0–90	Middle
2	F/42	2	7	54	Some stiffness in the DIP joint	7–90	8–50	Small
3	F/28	6	22	52	Early pin track infection	5–100	2–85	Ring
4	M/32	1	39	62	None	0–90	0–90	Middle
5	M/21	9	29	40	None	5–90	0–75	Small
6	M/21	5	43	35	Early pin track infection	15–75	2–90	Middle

ROM, range of motion; DIP, distal interphalangeal.

## Discussion

Fracture dislocations of the PIP joint are potentially disabling injuries when treated improperly or not treated at all. Early mobilization of the joint is necessary to avoid stiffness and permanent ankylosis. Many techniques to help decrease these side effects have been developed. Inanami et al.<sup>21</sup> described a

small dynamic external fixator composed of 2 rhomboid apparati that contained 2 pulleys at each end and one pulley in the middle. They were able to obtain optimal results with almost no complications; the final PIP joint range of motion was 88°. The hinge (Compass hinge; Smith & Nephew Richards, Memphis, TN) was reported on by both Bain et al<sup>18</sup> and



**Figure 5.** (A) Posteroanterior and lateral views after reduction of an intra-articular fracture dislocation of the PIP joint right small finger and placement of the dynamic fixator. (B) Posteroanterior and lateral views right after removal of the fixator. Notice an intra-articular step-off at the base of the middle phalanx. (C, D) Although some degenerative changes are depicted on the posteroanterior and lateral views at 12 months of follow-up evaluation, this patient had absolutely no pain and achieved functional range of motion.

Krakauer and Stern.<sup>27</sup> Both studies showed that this device was able to restore range of motion almost fully, however, many complications were encountered such as infections and breakage. It also tends to be a rather bulky as well as costly device. Skoff<sup>28</sup> described an apparatus composed of 2 K-wires. He reported a final range of motion of 115° at final follow-up evaluation on a single case with this device. This device relies on rubber bands, however, it is commonly known that rubber bands are susceptible to both plastic deformation and even breaking. The Agee<sup>15,16</sup> technique is built using 3 K-wires and is activated by a single rubber band. Rawes and Oni<sup>30</sup> reported that this technique led to a Swan-neck deformity.

Although all of these methods were fairly successful in reportedly allowing the patient to regain nearly full range of motion, most of the frames described earlier are either challenging for the surgeon or cumbersome to the patient. We have obtained better results just by applying the modifications to the dynamic fixator described by Gaul and Rosenberg.<sup>29</sup> This device is made of materials that are readily available and inexpensive. The procedure is relatively time efficient: assembly and application take less than 30 minutes. Our main goal was to ensure active range of PIP joint flexion extension even if some degree of subluxation was present.

We experienced only minor complications using this device (Table 1). We feel confident recommending this procedure as the preferred method for dealing with fracture dislocations of the PIP joint because it avoids more cumbersome methods fraught with complications.

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