

Distraction for Proximal Interphalangeal Joint Contractures: Long-Term Results

Shirzad Houshian, MD, Shan Shan Jing, MB, Gholam Hussein Kazemian, MD,
 Mohammad Emami-Moghaddam-Tehrani, MD

Purpose To report the medium- to long-term outcomes of joint distraction using a unilateral external fixator in the treatment of chronic post-traumatic proximal interphalangeal (PIP) joint contractures.

Method Between September 2001 and October 2011, 94 consecutive patients (98 PIP joints) with a mean age of 43 years (range, 17–69 y) were treated with external fixation for chronic flexion deformity of the PIP joint from trauma. The average time from injury to surgery was 48 months (range, 6–84 mo), and the duration of joint distraction was 10 days (range, 7–22 d). Patients were followed for a mean period of 54 months (range, 12–72 mo).

Results The average gain in joint flexion was 25° and in joint extension was 40°. The mean improvement in the active range of movement was 67° (range, 30°–90°). There was no loss of motion on the latest follow-up. Patients younger than 40 years fared slightly better than those older than 40 years. Two patients developed swelling, pain, and erythema during treatment, which resolved upon temporarily stopping the distraction process. There were 12 cases of superficial pin-site infections, which were managed conservatively without serious complications or adverse outcome.

Conclusions External fixation is a simple and effective treatment modality for chronic traumatic PIP joint contractures with good predictable medium- to long-term results. Careful patient selection and monitoring are required. (*J Hand Surg* 2013;38A:1951–1956. Copyright © 2013 by the American Society for Surgery of the Hand. All rights reserved.)

Type of study/level of evidence Therapeutic IV.

Key words Contracture, distraction, long-term, PIP joint.

FLEXION CONTRACTURE OF THE proximal interphalangeal (PIP) joint is a common yet complex clinical problem. It can lead to chronic pain, stiffness, and functional deficit particularly in severe

cases or if it affects several fingers.^{1,2} Early aggressive supervised therapy does not guarantee its prevention.³ Open surgical release is technically demanding and often leads to discouraging long-term results despite careful evaluation and patient selection.^{2–6} Surgical options for correcting PIP joint contractures include arthrolysis, tenolysis, capsulectomy/capsulectomy, local flaps, and skin grafts. Occasionally, arthrodesis or amputation is required in severe contractures.^{7,8} Sprague⁴ reported an eventual loss of the operative gain at 1-year follow-up. Ghidella et al² presented their results with a minimum follow-up of 24 months in 68 contracted PIP joints treated by serial capsulectomy. The average improvement in the range of active motion was 8°, and the revision rate was 35%.

From the Department of Orthopaedic Surgery, Braintree Community Hospital, Mid Essex; The Department of Plastic Surgery, Broomfield Hospital, Chelmsford, Mid Essex, United Kingdom; and Department of Orthopaedic Surgery, Imam Hossein Hospital, Shahid Beheshti University of Medical Science, Tehran, Iran.

Received for publication January 4, 2013; accepted in revised form July 19, 2013.

No benefits in any form have been received or will be received related directly or indirectly to the subject of this article.

Corresponding author: Shirzad Houshian, MD, Consultant Orthopaedic Surgeon, 77 Elwill Way, Beckenham, UK; e-mail: sh_houshian@yahoo.dk.

0363-5023/13/38A10-0010\$36.00/0
<http://dx.doi.org/10.1016/j.jhssa.2013.07.007>

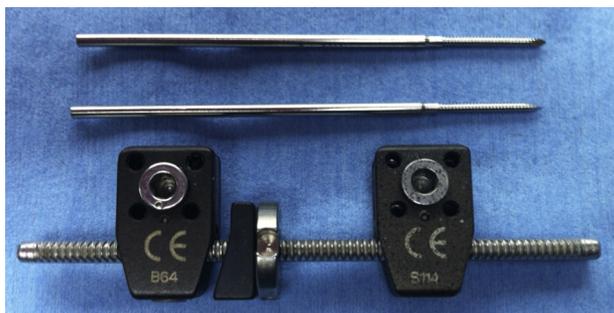


FIGURE 1: The Pennig mini-external Fixator system (Orthofix, Surrey, England).

In the past 20 years, external fixation of contracted PIP joints using the principle of ligamentotaxis distraction has been increasingly used.⁹ The technique is simple, effective, and minimally invasive. It avoids the complications of open surgery, which results in further soft tissue injury. In various reported series, it has produced good functional outcomes.^{7–16} We have previously reported our short-term results from dynamic external fixation in the management of post-traumatic PIP joint deformity.^{9,12,13} The average improvement in range of movement was between 42° and 63° compared with the 25° to 30° obtained from surgical releases reported in the literature.^{9,13–15,17}

We present the medium- to long-term results for 98 post-traumatic PIP joint flexion contractures treated by joint distraction using the Pennig mini-external fixator (Orthofix, Surrey, England) (Fig. 1) and discuss the key learning points from our experience with using this technique.

MATERIALS AND METHODS

Ninety-four consecutive patients (98 fingers) with post-traumatic chronic flexion contracture of the PIP joint that failed to respond to conservative treatment (extensive hand therapy and dynamic extension orthoses) were treated with the mini-external fixator between September 2001 and October 2011. Seventy-two patients were male and 22 were female with a mean age of 43 years (range, 17–69 y). The decision to operate was based on the degree of functional deformity (PIP joint contracture, > 60°) on presentation and the patient's choice following a discussion of treatment options. The average time from injury to surgery was 48 months (range, 6–84 mo). The types of traumatic PIP joint injuries included volar lip fractures of the middle phalanx base with volar avulsion fracture at the base of the middle phalanx (44) (Fig. 2), volar dislocation with dorsal avulsion fracture of the middle phalanx (22), and joint dislocation without fracture (28,



FIGURE 2: Lateral radiograph of a left little finger PIP joint contracture following a volar avulsion fracture of the middle phalanx.

including 4 joint subluxations). The index finger was involved in 16 cases, middle finger in 21, ring finger in 30, and small finger in 31. In all patients, preoperative plain radiographs of the injured joint had showed no sign of osteoarthritis or joint incongruity. Ethical approval was not required because the technique is now an established form of treatment in our institute, and approval had been previously obtained.⁹

Contractures following burn, Dupuytren disease, congenital hand anomaly, severe crush injury, and replantation were excluded from this study as were patients younger than 18 years or older than 70 years.

We collected data on the duration of distraction, the range of movement of the injured joint before and after treatment, and the postoperative complications. Results from patients younger than 40 years and 40 years old or older were compared.

Surgical technique

Under local or regional anesthesia, a unilateral dynamic Pennig mini-external fixator (Orthofix, Surrey, England) was positioned under image intensifier control. A 2-mm threaded half pin was inserted perpendicular to the cortices of the proximal and middle phalanges. The pins were placed parallel to

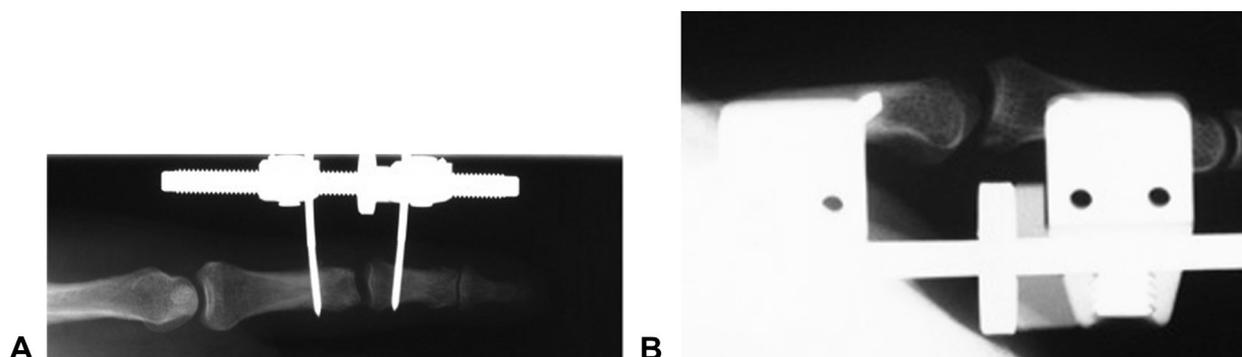


FIGURE 3: Anteroposterior **A** and lateral **B** radiographs show a 5-mm even joint distraction of the left little finger PIP joint illustrated in Figure 2.

each other and at approximately equal distance from the articular surfaces of the PIP joint. A clamp was attached to each pin. A lengthening bar was placed between the clamps with the distraction nut and spacer in direct contact with the distal clamp on its proximal side. The clamps were then locked to the pins and the lengthening bar. The clamps were positioned at least 10 mm from the skin to allow for swelling. The distraction nut was turned until 1 mm of PIP joint distraction was obtained.

After surgery, patients were allowed to mobilize the unaffected joints immediately. They were taught to turn the distraction nut by a quarter turn twice daily (1 full turn provides a 1-mm distraction), starting 1 day after surgery. All patients were advised (particularly in the presence of long-standing severe PIP joint contracture) to take 1 g of acetaminophen 1 hour before distraction. Patients were monitored on a weekly basis with careful examination of the neurovascular status of the distracted finger. The process of distraction was stopped once a 5-mm joint opening or full extension of the PIP joint was achieved (Fig. 3). Our previous comparative study on different distraction rate had demonstrated that 5 mm of joint distraction was sufficient to achieve the optimum effect.¹¹ The device was left in place for a minimum of 1 week and removed without anesthesia. This follows from our previous study, which had demonstrated that the fixator needed to be kept in place for only 1 week to maintain the functional gain once the desired amount of distraction was achieved.¹¹

Care was taken to release the overdistracted gradually on removal of the fixator to prevent the articular surfaces from suddenly recoiling toward each other, which can cause severe pain. Supervised hand therapy continued for 4 weeks thereafter. Plain radiographs were taken at 1 and 2 weeks (in patients who had longer period of distraction) after surgery and following the removal of the fixator, unless

otherwise indicated. The mean duration of follow-up was 54 months (range, 12–72 mo).

The improvement in the active range of movement of the distracted joint was assessed using paired student *t*-test. A *P* value less than .05 was considered significant.

RESULTS

The mean duration of distraction was 10 days (range, 7–22 d). The fixator was removed at an average of 19 days (range, 14–40 d). Table 1 illustrates the improvement in flexion, extension, and active range of movement before and after surgery at 1, 3, and 6 months and on final follow-up. The average gain in joint flexion was 25° and in joint extension was 40°. The mean improvement in the active range of movement after surgery was 67° (range, 30°–90°; *P* < .001). Patients younger than 40 fared slightly better than those 40 years old and older (Table 2), but this difference was not statistically significant (*P* = .149).

In 12 long-standing and stiff joint contractures, we observed bending of the half pins (Fig. 4). This was because a greater force of distraction was required, which was partially absorbed by the half pins. Distraction occurred secondarily at the joint itself. No pins broke. Patients tolerated the discomfort of distraction with simple analgesics.

1. In flexion deformities of greater than 80°, we noted asymmetrical joint opening in 7 cases (Fig. 4). The joint opened more on the side adjacent to the fixator.
2. Two patients with hypermobile joints had subluxation of the PIP joint. The first patient reported feeling a snap on day 2 after surgery. X-rays showed joint subluxation and opening of 4 mm. Distraction was stopped immediately, and the fixator was removed a week later. In the second patient, we reduced the distraction rate to half. X-rays were taken every 3 days for monitoring. Distraction

TABLE 1. Pre- and Postoperative Range of Motion

Range of Motion	Mean \pm SD ($^{\circ}$)	Range ($^{\circ}$)
Preoperative AROM	18 \pm 16	0–50
Preoperative finger extension/flexion	50/65 \pm 7/9	
Postoperative AROM		
At 1 mo	64 \pm 14	40–90
At 3 mo	85 \pm 11	50–100
At 6 mo	85 \pm 11	50–100
At final follow-up evaluation	85 \pm 11	50–100
Postoperative finger extension/flexion		
At 1 mo	24/85 \pm 7/8	
At 3 mo	10/90 \pm 10/5	
At 6 mo	10/90 \pm 10/5	
At final follow-up evaluation	10/90 \pm 10/5	
AROM gain	67 \pm 17	30–90
Inference	ROM gained is statistically significant with student's <i>t</i> -test ($t = 19.775$; $P < .001$)	

This table illustrates the flexion, extension, and AROM in 94 post-traumatic chronic flexion contractures of the proximal interphalangeal joint before and after surgery following treatment with a monolateral external fixator.

AROM, active range of movement.

TABLE 2. Range of Motion Gained Between Different Age Groups

Age (y)	Range	Mean \pm SD
< 40	30–90	66.55 \pm 17.92
\geq 40	30–70	55.00 \pm 13.89
Overall	30–90	67.00 \pm 17.36
Inference	Reduced ROM gain for the elderly older than 40 y with $P = .149$	

Although patients younger than 40 y fared better than those age 40 y or older, the difference was not statistically significant. The outcome from joint distraction for chronic PIP joint contracture is unlikely to be related to age.

ROM, range of motion.

was stopped before subluxation. Both patients achieved joint distraction of 4 to 5 mm and managed to keep the fixator in place for 1 week to allow maturation of the lengthened soft tissue. The final result was not affected.

- Twenty patients had temporary flexion deformity of the distal interphalangeal joint of the distracted

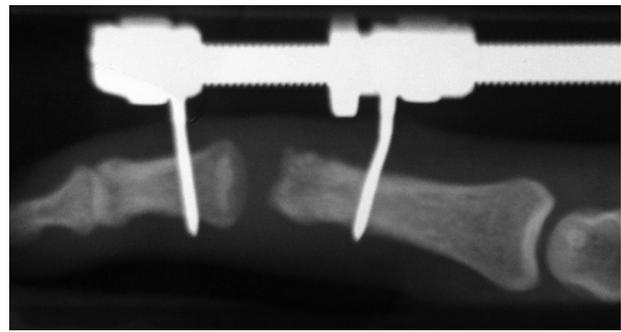


FIGURE 4: Anteroposterior radiograph illustrates the asymmetrical joint distraction and bending of a half pin in a severe and longstanding contracture of the little finger PIP joint.



FIGURE 5: Swelling and redness of the distracted PIP joint, particularly on the volar aspect, during treatment.

finger. Twelve were severe ($> 40^{\circ}$ flexion), and a modified mallet orthosis was given. The rest were treated with hand therapy. No patient had residual deformity at the distal interphalangeal joint after treatment.

- Two patients developed swelling and redness on the volar aspect of the distracted joint (Fig. 5). The distraction was temporarily stopped and then resumed once the inflammation resolved. One patient was later determined to have mild Raynaud disease.
- Superficial pin-track infections were seen in 12 cases (12%). These were treated with oral antibiotics and local wound care. None of the patients had pin loosening or interruption of treatment.
- Fourteen patients had mild pain on initial distraction. The treatment was well tolerated with simple analgesia before turning the distraction nut. One patient developed pain at the pin sites. This resolved by halving the distraction rate. No patient had chronic pain.

All patients achieved good results and were satisfied with the final aesthetic results.

DISCUSSION

Schenk¹⁸ described the use of external fixation for correcting chronic flexion deformity of the PIP joint as did Richtr and Rysavý¹⁴ 5 years later. For the past 10 years, this technique has been increasingly used. It allows the release of contractures even in the most resistant of cases. Various apparatuses have been tested. A simple uniplanar construct such as the Joshi external stabilizing system has been used to treat contractures in leprosy and following burns with reported good results.^{8,10} A more complex multiplanar distractor for contracture after finger replantation has also been described.¹⁹

Bain et al²⁰ introduced the dynamic extension technique using a hinge external fixator for PIP joint flexion contractures and reported good results in 2 cases. In 2002, we reported the use of a similar hinge fixator for contractures of 27 PIP joints in which we achieved a mean improvement in flexion contracture of 38° and active range of motion of 42°. ¹³ Despite this, the majority of our patients had a residual extension lag of approximately 15°. This occurred owing to inadequate distraction resulting in partial correction of the deformity, particularly on the volar aspect of the joint.

We have previously used the Pennig mini-external fixator as a distraction device to manage neglected dorsal fracture-dislocations of PIP joint; Rolando fractures, and late presentation of intra-articular displaced metacarpal and phalangeal head fractures.^{21–23} We have found it safe and easy to apply. We have had no long-term complications such as chronic regional pain syndrome. Our early case series in which we treated 10 and 30 PIP joint contractures using this system gained 54° to 63° in flexion and 47° in extension. The operative gain was maintained up to 34 months after surgery, and only 1 week with the fixation in place was required to mature the lengthened soft tissue.^{12,13} In our opinion, the distraction device is effective because it lengthens the periarticular structures, particularly the volar plate, more so than the extension device. This results in soft tissue laxity, restores the normal anatomy, and corrects the deformity. The Pennig apparatus also produces better-controlled and gradual ligamentous distraction compared with other constructs. It requires only 2 pins and, therefore, reduces the risk of soft tissue injury and pin site infection.

The patient's age has previously been described as an important prognostic factor after open contracture releases. Iselin and Revol²⁴ obtained 75% satisfactory results in patients younger than 27 years old, but only 22% in the older group. Ghidella et al² discouraged attempts at correcting PIP joint contractures in patients

older than 43 years, which was significantly associated with poorer outcomes. In this study, we did not identify an age-related difference in outcome using external fixation.¹² This may be because the procedure is less invasive than the open approach.

Ravishankar¹⁰ reported the long-term results from external fixation in 94 burn contractures of the PIP joint. He noted a loss of motion over time during a follow-up of 54 months, a finding also observed after open procedures.⁴ Ghidella et al² reported that there was probably little difference in the expected joint movements after 24 months. However, we have demonstrated that the operative gain in the range of movement can be maintained up to 72 months by joint distraction with no long-term complication.

Key learning points from medium- to long-term joint distraction

In the presence of severe and long-standing PIP joint contractures, deformity of the half pins and asymmetrical joint distraction can be expected. These patients require a longer period of distraction to achieve a 5-mm gap in the PIP joint. Distraction should be stopped once the joint has opened up by 5 mm. Plain radiographs are mandatory to monitor for the rate of distraction and prevent the half pin from fracturing. Preoperative planning and patient selection are essential. Presence of hypermobile joints and microvascular disease must be identified before treatment. Patients should be counselled about temporary flexion deformity of the distal interphalangeal joint. This may have resulted from lengthening of the extensor tendon apparatus during distraction or from chronic joint flexion contracture leading to imbalanced action of the flexor tendons on the undistracted distal interphalangeal joints. Prophylactic splinting may be required during treatment.

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