

# Distraction Correction of Chronic Flexion Contractures of PIP Joint: Comparison Between Two Distraction Rates

Shirzad Houshian, MD, Chandrasekar Chikkamuniyappa, MS

From the Department of Orthopaedics, Upper Limb Unit, University Hospital Lewisham, London, UK.

**Purpose:** The surgical correction of chronic flexion contractures of the proximal interphalangeal (PIP) joints is quite challenging because the extensive soft-tissue surgery needed is demanding, and the results often are discouraging. Gradual joint distraction recently was shown to be effective in the correction of PIP joint contractures. We performed this study to determine the optimum rate and amount of daily distraction and the optimum duration for which the external fixator should be left *in situ* after correction. This study compared 2 groups of patients with different distraction rates: one group with 0.5 mm/day and the other group with 1.0 mm/day. We also compared and evaluated the results of external fixation removal at 1 week versus 2 weeks after full correction.

**Methods:** The Mini-Orthofix external fixator was used to correct post-traumatic PIP joint contractures in 10 consecutive patients divided into 2 groups. Group 1 consisted of 5 patients who had 0.5 mm of joint distraction per day until full correction followed by an *in situ* external fixator for 2 weeks. Group 2 consisted of 5 patients who had 1 mm of joint distraction per day until full correction followed by an *in situ* external fixator for only 1 week. The 2 groups were compared and statistically analyzed.

**Results:** At the 1-year follow-up evaluation there were no statistically significant differences between the 2 groups. The mean range of motion gained was 64° in group 1 and 66° in group 2. There were no recurrences.

**Conclusions:** We concluded that 1 mm of joint distraction per day followed by an *in situ* external fixator for 1 week may be safe and effective for the correction of chronic post-traumatic contractures of the PIP joint; however, similar studies on a larger group may be necessary before this technique could be recommended universally. (J Hand Surg 2007;32A: 651–656. Copyright © 2007 by the American Society for Surgery of the Hand.)

**Type of study/level of evidence:** Therapeutic I.

**Key words:** Chronic joint contractures, distraction correction, external fixator, proximal interphalangeal joint.

The surgical correction of chronic flexion contractures of the proximal interphalangeal (PIP) joints is quite challenging. The extensive soft-tissue surgery needed is demanding, and the results often are discouraging.<sup>1–3</sup> Gradual dynamic extension and/or gradual joint distraction (arthrodiastasis) using an external fixator was shown to be effective recently in the correction of PIP joint contracture with good results.<sup>4–6</sup>

Until now the rate of daily distraction during arthrodiastasis has been the individual preference of the operating surgeon. Distraction rates ranging from

0.25 to 1 mm/day have been reported.<sup>5–7</sup> This study investigated the optimum rate and amount of daily distraction and the optimum duration for which an external fixator should be left *in situ* after correction. The principle of distraction histogenesis allows us to distract up to 1 mm/day.

The purpose of the present prospective study was to evaluate whether a faster distraction and a shorter period of external fixation is an effective and safe method for the correction of PIP joint contractures caused by fracture dislocation. In this study we compared 2 groups of patients with different distraction

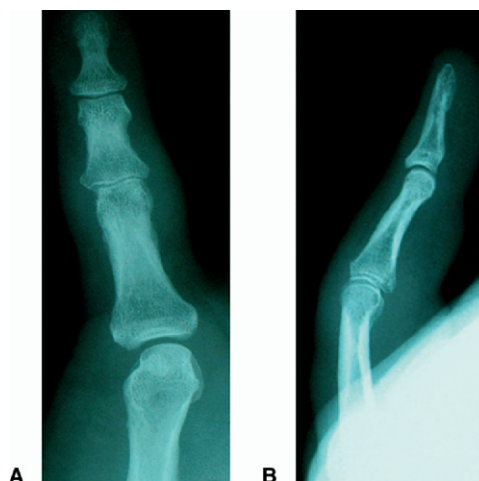


**Figure 1.** Clinical picture of the Pennig Mini-External Fixator *in situ*.

rates, one group with 0.5 mm/day (our current standard distraction rate from previous experience) and the other group with 1 mm/day (the optimum rate for distraction histogenesis). We also evaluated the results of a quicker removal of the external fixation device after full correction, that is, device times of 2 weeks (our standard practice) compared with that of 1 week after full correction.

The Pennig Mini-Orthofix external fixator (Orthofix, Surrey, England) was used in this study. Using image intensifier guidance and local anesthesia, a 2-mm threaded wire was inserted perpendicular to the proximal phalanx in the coronal plane. A standard clamp was applied over the wire and the wire then was trimmed. Only a dummy wire was inserted in the second hole of the clamp and trimmed (Fig. 1). The short, threaded, lengthening bar with a spacer (the angled side was in contact with the standard clamp) was attached to the clamp with the distraction nut. The second clamp then was attached to the threaded bar and a second 2-mm threaded wire was inserted into the middle phalanx, parallel to the first wire at equal distance to the PIP joint. The clamps and cams were locked to the wire and to the lengthening bar. The clamp and lengthening bar were placed volarly to gain a combination of distraction and extension.

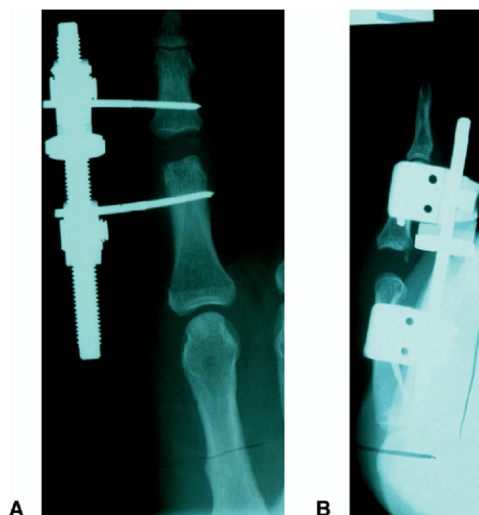
The clamps were positioned at least 5 mm from the skin to allow for postoperative swelling. The patient was taught to turn the distraction nut by a quarter turn twice daily in one group and by a half turn twice daily in the second group (1 full turn provides 1 mm of joint distraction), allowing progressive passive



**Figure 2.** (A) Anteroposterior and (B) lateral radiographs showing healed fracture dislocation of the PIP joint in 40° of fixed flexion of the small finger.

extension starting on the day after surgery. None of the patients received prophylactic antibiotics. The patients were trained to perform the distraction by themselves at home, attending weekly reviews in the orthopedic outpatient clinic. When complete extension and a joint distraction of 5 mm (Figs. 2, 3) was reached, the distraction was stopped and the device was left in place for a further 2 weeks in group 1 and for another 1 week in group 2. The device then was removed from all patients in the outpatient clinic without anesthesia.

Supervised hand therapy was instituted for 4 weeks after removal of the fixator. During distraction the neurovascular status of the finger was monitored closely.



**Figure 3.** (A) Anteroposterior and (B) lateral radiographs of the PIP joint with Orthofix placement showing 5 mm of joint distraction.

**Table 1. Distractor Rates and Post-Correction Delays in the Removal of External Fixator in the Two Groups**

	Group 1	Group 2
Rate of distraction	0.25 mm twice daily	0.5 mm twice daily
Postcorrection delay in removal of external fixator	2 wk	1 wk

## Patients and Methods

Ten fingers in 10 patients with chronic flexion contractures of the PIP joints caused by fracture dislocation were included in this prospective study. The patients were divided into 2 groups of 5 patients each (Table 1) by the admissions office, who were unaware of the diagnosis and the type of surgery being proposed.

Group 1 consisted of 5 patients who had 0.5 mm of distraction per day (a quarter turn twice daily) until full correction was achieved, followed by leaving the device *in situ* for 2 weeks. This group also represents our current standard practice.

Group 2 consisted of 5 patients who had 1 mm of distraction per day (a half turn twice daily) until full correction was achieved, followed by leaving the device *in situ* for only 1 week.

All patients had their initial treatment for their fracture dislocation in the form of closed reduction and either buddy strapping or plaster of Paris. Because these patients were referred secondarily for their contractures, the exact treatment details were difficult to confirm. Intra-articular fractures, when present, involved less than a third of the articular surface, as assessed in the lateral radiographs. There was no gross incongruity of the joint surfaces. No patients had signs of osteoarthritis of the PIP joint in this series.

Our indications for this procedure include patients with post-traumatic chronic flexion contractures caused either by dislocation or fracture dislocation around the PIP joint in a skeletally mature patient. All patients should have received extensive hand therapy for a minimum period of 3 months before surgery with no benefit.

We do not recommend this procedure in contractures resulting from other causes such as postburn contractures, Dupuytren's contractures, congenital malformations, chronic regional pain disorders, and contractures caused by crush injuries, tendon lacerations, or replantations.

All patients were reviewed once a week during treatment after surgery and at 1, 3, 6, and 12 months after fixator removal. During each consultation the degree of pain experienced (assessed using a visual analogue scale [VAS]) and the range of motion (ROM) were evaluated. Patient satisfaction with regard to appearance and symptom relief also was documented.

All patients had been treated with extensive hand therapy and dynamic extension splints before surgery, with no benefit. None of the patients had any previous surgeries for their contractures.

## Results

The patient results are as shown in Table 2. Statistically there was no significant difference between the 2 groups with respect to the mean ROM gained ( $p = .875$ ). There was a significant difference between the groups, however, with regard to the total duration of external fixation and distraction ( $p < .01$ ) (Table 3).

Clinical data are shown in Tables 1 and 2. The mean ages of the patients in groups 1 and 2 were 32 years (range, 24–42 y) and 35 years (range, 22–47 y), respectively. The mean time from injury to surgery in group 1 was 15 months (range, 12–20 mo) and in group 2 was 16 months (range, 7–24 mo). In group 1 the mean distraction time was 20 days, and in group 2 the mean distraction time was 11 days. The mean duration of external fixation in group 1 was 34 days, and in group 2 it was 17 days. The average ROM of the PIP joint before surgery was 18° (SD, 25°) for group 1 and 18° (SD, 11°) for group 2. The mean ROM gained by the procedure amounted to 64° in group 1 and 66° in group 2 ( $p = .065$ ) (Fig. 4).

No complications were encountered in this series. One patient in group 1 (VAS = 3) and 2 patients in group 2 (VAS = 3 and 2) experienced pain during distraction; however, all 3 patients could tolerate the fixator without interrupting the treatment. Pain in all 3 patients was related to the distraction itself. We recommend that if the VAS score is 5 or greater or if there is impending neurovascular compromise, then the distraction should be delayed by 1 to 2 days. The distraction should proceed after re-evaluating the VAS score and neurovascular status.

None of the patients reported any pain during the follow-up evaluation. At the 1-year follow-up evaluation, all patients in both groups were satisfied with the results. None of the patients had a loss of flexion during or after the procedure. There were no recurrences.

**Table 2. Clinical Data of the Two Groups Before and After Surgery**

Patient	Age, y	Gender	Digit	Injury to Surgery Interval, mo	Duration of Distraction, d	Duration of External Fixation, d	ROM Before Surgery, °	ROM at 12 Months, °	Motion Gained, °
Group 1									
1	24	M	Small	20	20	34	60/60	0/90	90
2	34	F	Small	15	21	35	60/60	10/80	70
3	30	M	Small	16	22	36	40/40	10/90	80
4	42	M	Index	12	16	30	40/90	0/90	40
5	29	M	Ring	14	19	33	50/90	10/90	40
Mean	32			15	20	34			64
Group 2									
1	37	F	Index	7	12	19	50/50	0/90	90
2	22	M	Small	18	10	17	40/60	10/90	60
3	46	M	Ring	14	11	16	40/60	10/80	50
4	23	M	Middle	15	12	19	60/90	0/100	70
5	47	M	Small	24	10	17	40/60	10/90	60
Mean	35			16	11	17			66

° = degrees.

## Discussion

Since the graphic description of the open surgical release by Curtis,<sup>8,9</sup> several investigators have reported either modification of or alternative open techniques with variable success rates.<sup>2,10–13</sup> Overall, these methods are demanding and the results are unpredictable and often discouraging.<sup>10</sup>

Although the principle of distraction histogenesis has been well established, its application in correcting flexion contractures of the PIP joint with external fixation has been documented only recently in the literature. Patel and Joshi<sup>7</sup> reported distraction with subsequent mobilization to manage chronically dislocated PIP joints. Bain et al<sup>14</sup> introduced a dynamic extension technique using a Compass-Hinge external fixator (Smith & Nephew Richards, Memphis, TN) for PIP flexion contractures in 2 patients. Kasabian et al<sup>15</sup> reported using a multiplanar distractor in a single patient with a severe contracture. We have used a

Compass Hinge previously for dynamic extension correction in 27 patients and we reported a mean extension gain of 38°, with a mean arc of motion gain of 42° (range, 0°– 80°).<sup>4</sup>

Although we had good results with this technique, there were some problems. First, it was a rather demanding technique in which pin placement was important to reproduce the arc of PIP joint motion (the axis of rotation in the head of the proximal phalanx). Slight misplacement resulted in a compromised outcome. Second, in our earlier series,<sup>4</sup> most of the PIP joints still had 10° to 30° of persistent flexion deformity even when the device was extended fully. We believe that this was caused by the weak construct of the compass hinge itself because it uses a 1-mm K-wire, which tends to bend at the terminal extension.

It also was difficult to obtain hyperextension with the compass hinge, which often was necessary to

**Table 3. Comparison of ROM Between Both Groups**

	Group 1, Mean ± SD	Group 2, Mean ± SD
ROM before surgery, °	18 ± 25	18 ± 11
ROM at 12 months, °	82 ± 8	84 ± 11
Significance by paired <i>t</i> test	0.003	0.001
Effect size, <i>d</i>	3.84	5.91

Group 2 produced 54% (5.91/3.84 \* 100) additional effect when compared with group 1.

No effect,  $d < 0.20$ ; mild effect,  $0.20 < d < 0.50$ ; moderate effect,  $0.50 < d < 0.80$ ; large effect,  $0.80 < d < 1.20$ ; very large effect,  $d > 1.20$ .

° = degrees.



**Figure 4.** Clinical pictures of patient in Figure 2, showing the final outcome at the 1-year follow-up evaluation (PIP joint of small finger).

correct the deformity fully. We also had a 22% recurrence rate in these patients.<sup>4</sup> Because of all these problems, we explored other available minifixators for the purpose of distraction correction.

Distraction correction, as used in this study, differs from extension correction using the Compass Hinge because contractures get corrected automatically when the joint is subjected to gradual distraction, with the distracter placed volar to the PIP joint. By distracting, the offending structures responsible for contractures, such as the capsule, the collateral ligaments, and the palmar plate with the check rein ligaments, are lengthened. This distraction restores the length of the contracted structures, and also distracting the articular surfaces (arthrodiastasis).

Regarding the amount of distraction, Patel and Joshi<sup>7</sup> reported 2 to 5 mm of joint distraction for reduction of dorsal dislocations. Gulati et al<sup>16</sup> reported 2 to 3 mm of joint distraction in small finger joints. We earlier reported a PIP joint distraction of 3 to 5 mm for better correction.<sup>5</sup> In this study, however, we standardized the amount of distraction by performing 5-mm joint distraction in all patients.

Ravishanker<sup>6</sup> used a 0.5-mm distraction rate twice daily (1 mm/24 h). Patel and Joshi<sup>7</sup> used a fixation device distracting every hour of the day when the patient was awake (0.5 mm/24 h), allowing their patients to alter the distraction rate between 0.25 mm/24 hours and 0.5 mm/24 hours as tolerated. A standard distraction rate of 0.5 mm/day in 2 installments was found to be adequate in our previous study.<sup>5</sup> We used this rate in group 1 (our current standard practice), whereas in group 2 a 1-mm distraction in 2 installments was performed. Statistically there was no significant difference between these 2 groups ( $p = .065$ ) in the final outcome.

Ravishanker<sup>6</sup> left the external fixator *in situ* for 4 weeks after full correction; however, we believe that this is too long and may result in stiffness. Our standard additional device time has been 2 weeks after full correction. We used this timeframe in group 1 patients. We removed the fixator at the end of 1 week for group 2 patients. This was prompted by our past observations. In some of our patients we were forced to remove the device earlier than 2 weeks, either because of pin track infections or patient compliance. This did not effect our results. A lack of noteworthy differences between the groups in the present study reinforced our earlier observation that additional device time of only 1 week after full correction may be adequate for a satisfactory outcome.

All of our patients tolerated the standard distraction rates, although 2 patients in group 2 and 1 patient in group 1 had some discomfort immediately after distraction, but it did not affect the treatment. The majority of patients experienced slight pain for a few minutes after distraction, but it resolved without the need for analgesia. Persistent pain, however, should lead to suspicion of a neurovascular problem.

Our earlier experience with the compass hinge and passive extension correction produced an average motion gain of 42°.<sup>4</sup> With the Orthofix and distraction correction, there was 54° of average motion gain.<sup>5</sup> The patients in these studies had similar profiles.

This was a small series of 2 groups involving different distraction rates and different additional device times (a concerning limitation in this study); however, we believe they are representative of the described distraction techniques. The lack of noteworthy differences between the 2 groups in the final outcome helped us to conclude that 1 mm of joint distraction per day followed by an *in situ* external fixator for 1 week after full correction is safe and effective. Similar studies on a larger group of patients may be necessary before the technique could be recommended universally.

Received for publication August 11, 2006; accepted in revised form February 20, 2007.

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

Corresponding author: Shirzad Houshian, MD, Consultant Orthopaedic Surgeon, Department of Orthopaedics, Upper Limb Unit, University Hospital Lewisham, SE13 6LH, London, UK; e-mail: shirzad.houshian@uhl.nhs.uk.

Copyright © 2007 by the American Society for Surgery of the Hand 0363-5023/07/32A05-0011\$32.00/0  
doi:10.1016/j.jhsa.2007.02.015

## References

1. Foucher G, Lenoble E, Ben Youssef K, Sammut D. A post-operative regime after digital flexor tenolysis. A series of 72 patients. *J Hand Surg* 1993;18B:35–40.
2. Ghidella SD, Segalman KA, Murphey MS. Long-term results of surgical management of proximal interphalangeal joint contracture. *J Hand Surg* 2002;27A:799–805.
3. Koller VR, Choi MS, Bayer GS, Millesi H. Analysis der veränderung der fingerfunktion nach beugertenolyse. *Handchir Mikrochir Plast Chir* 1996;28:204–209.
4. Houshian S, Gynning B, Schroder HA. Chronic flexion contracture of proximal interphalangeal joint treated with the compass hinge external fixator. A consecutive series of 27 cases. *J Hand Surg* 2002;27B:356–358.
5. Houshian S, Schroder HA. Distraction with external fixator for contractures of proximal interphalangeal joints: good outcome in 10 cases. *Acta Orthop Scand* 2004;75:225–228.
6. Ravishanker R. Distraction correction for flexion contractures of the fingers: a minimally invasive technique. *Indian J Plast Surg* 2003;36:99–103.
7. Patel MR, Joshi BB. Distraction method for chronic dorsal fracture dislocation of the proximal interphalangeal joint. *Hand Clin* 1994;10:327–337.
8. Curtis RM. Capsulectomy of the interphalangeal joints of the fingers. *J Bone Joint Surg* 1954;36A:1219–1232.
9. Curtis RM. Management of the stiff proximal interphalangeal joint. *Hand* 1969;1:32–37.
10. Sprague BL. Proximal interphalangeal joint contractures and their treatment. *J Trauma* 1976;16:259–265.
11. Harrison DH. The stiff proximal interphalangeal joint. *Hand* 1977;9:240–243.
12. Watson HK, Light TR, Johnson TR. Check rein resection for flexion contracture of the middle joint. *J Hand Surg* 1979;4A:67–71.
13. Diao E, Eaton RG. Total collateral ligament excision for contractures of the proximal interphalangeal joint. *J Hand Surg* 1993;18A:395–402.
14. Bain GI, Mehta JA, Heptinstall RJ, Bria M. Dynamic external fixation for injuries of the proximal interphalangeal joint. *J Bone Joint Surg* 1998;80B:1014–1019.
15. Kasabian A, McCarthy J, Karp N. Use of a multiplanar distracter for the correction of a proximal interphalangeal joint contracture. *Ann Plast Surg* 1998;40:378–381.
16. Gulati S, Joshi BB, Milner SM. Use of Joshi External Stabilizing System in postburn contractures of the hand and wrist: a 20-year experience. *J Burn Care Rehabil* 2004;25:416–420.