Early Results of A Simple Distraction Dynamic External Fixator in Management of Comminuted Intra-Articular Fractures of Base of Middle Phalanx

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Abstract Treatment for comminuted fracture dislocations of the proximal interphalangeal joint (pilon injuries) remains a challenge. We present our short term results of twelve pilon fracture dislocations treated by closed reduction and application of a distraction dynamic external fixator. The aim of the study was to assess the clinical outcomes and compare them to the original description by Hynes and Giddins. A cohort of 12 consecutive patients with pilon fracture of the proximal interphalangeal joint (comminuted fracture of the base of middle phalanx, longitudinally unstable with joint subluxation), were treated with this method over the study period. Data was collected by an independent observer at last follow-up appointment in the clinic. The outcome measures recorded were; level of residual pain, arc of motion, X-ray appearance, return to work and satisfaction with the procedure. The study group comprises of 7 male and 5 female patients at a mean age of 38.1 years (range 21–70 years). The average range of movement achieved was 13–87° at a mean follow-up of 16.4 weeks (Range 12–42 weeks). Early return to work, good pain relief and high level of patient satisfaction were achieved. No serious complication was noted during this period. We used the construct with slight modification of the original description and we feel this modification may help to reduce the pin site infection. We found the results reproducible and based on our experience we recommend this technique to treat these complex intra-articular fractures of base of middle phalanx.

Keywords Giddin's frame · Intra-articular base of phalanx fracture · Management · Distraction dynamic external fixator

Introduction

Injury to the PIP joint may lead to considerable loss of hand function and consequent disability. Comminuted intra-articular fractures of the base of middle phalanx, also known as 'Pilon' fractures are common in ball sports [1]. They occur as a result of hyperextension and axial loading which causes depression of the central articular fragments and splaying of the fragments at the periphery of the affected bone. Disruption in the continuity of the palmar restraints of the collateral ligaments and palmar plate complex with the bony buttress provided by the palmar lip of the middle phalanx base allow dorsal subluxation [2]. Neglect or improper treatment of these fractures is associated with pain, stiffness, instability and degenerative arthritis [3].

These fractures are difficult to treat and remain a challenging problem. Several operative and non-operative techniques and approaches have been devised, but consensus is still lacking as to the indication of each or the best approach to treatment [4]. Conservative management comprising of immobilisation and splintage alone had shown poor outcome in term of stiffness, pain and markedly reduced range of movement [5]. Open reduction and internal fixation is often technically difficult because of comminution of the bone fragments and stiffness is a usual problem [6]. To overcome these problems, a variety of static and dynamic external fixation devices have been designed to treat such fractures of the PIP joints. The ability to provide both, distraction at the fracture site and active mobilisation may offer the best solution to the management of many of these fractures [7–12].

The distraction dynamic external fixator (DDEF) designed by Hynes and Giddins [13] is a relatively simple type of fixator that uses widely available equipment (1.1 mm K-wire). This provides stability, distraction and allows early mobilization. In our series of 12 patients, we used this frame in reverse to the original description. The aim of the study was to assess the clinical outcomes of DDEF compared to the original description and its reproducibility.

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Methods

A cohort of 12 consecutive patients, who required surgical intervention for PIP joint pilon fracture (comminuted fracture of the base of middle phalanx involving PIP joint, longitudinally unstable with joint subluxation), were treated with this method over the study period. The surgery was performed as day case procedure. With the exception of one patient, anaesthesia consisted of a digital block.

Technical Details of Reverse Construct

Using a mini C-arm fluoroscopy machine for X-ray imaging, a 1.1 mm K-wire was passed transversely in the coronal plane through the centre of the head of proximal phalanx. Another 1.1 mm K-wire was then passed transversely in the coronal plane through the mid-shaft of the middle phalanx, parallel to the first wire, and perpendicular to the long axis of middle phalanx. The distal K-wire was bent to 90° on both side of finger at a distance of 3 to 5 mm from the skin surface. The ends of the distal wire are bent and hooked around the proximal wire to create a hinge and spring distractor (Fig. 1). This distraction holds the fracture out to the length and allows movement at the PIP joint (Figs. 1 and 2).

We used the construct in reverse to the original description by Hynes and Giddins [13]. The proximal wire was not

Fig. 1 X-ray picture showing the construct –in reverse than the original description

Fig. 2 photograph showing the construct

bent (to make it static - so that it does not move with the movement of joint), instead the distal wire was bent at 90° and hooked around the proximal wire to produce movement at wire –wire interface where it make a hinge around the proximal wire. Furthermore the angle at the hinge can be adjusted to adjust the tension at PIPJ. A K-wire was used as joy stick to elevate the central depression if the reduction was not complete with simple distraction. Once reduced the fixator was enough to maintain that reduction except in one case where the K-wire was left in as an additional support and was taken out at 6 weeks.

Range of motion was permitted immediately after surgery and physiotherapy began within one to four days. The patients were instructed to allow running water from a tap or shower over the K-wires to clean the pin-sites. Patients were followed up in outpatient clinic at 1, 2, 3, 6 and 12 weeks with x-rays at each visit along with clinical examination including measurement of the arc of motion. Regular physiotherapy with initial active mobilization was built up to passive mobilization as pain allowed. The patients were also instructed in oedema management. The fixator was removed in outpatient clinic after 6 weeks of its application.

Final outcome measurements were recorded by the same investigator (MM) independent of the surgeons performing the procedures at a mean follow-up of 16.4 weeks with range from 12 to 40 weeks. The patients were asked to record their current level of pain on a visual analogue scale (0 equals no pain, 10 equals worst pain ever). Measurements of PIP joint movement were taken with a finger goniometer. Patients were asked about return to work and their satisfaction level on a scale of 0 to 10 (0 equals very unsatisfied, 10 equals completely satisfied). Complications or problems, if any, were also recorded.

Results

Eleven out of the 12 patients attended the follow-up clinic at a mean of 16.4 weeks. Seven male and five female patients with the mean age of 38.1 years (range 21–70 years), were

treated with DDEF. The average arc of movement achieved at the PIP joint was from 13° to 87° which was comparable to 12 to 88° in the original work [13]. Nine out of the 11 patients were pain free; three patients described occasional mild pain scoring 1–2, on the scale described above. The procedure satisfaction score was 9–10 out of 10 in all cases except one who scored at 6. One patient was lost to follow up (Table 1).

Final X-ray appearance was satisfactory in all cases with no subluxation or coronal plane angulation.

Nine patients were working prior to injury, 3 went back to their jobs next day, 1 on third and 1 on eighth post operative day with the frame on. One patient returned to work at 2 weeks post-operatively as it was his planned holidays. Two patients were not allowed to return to work by their employers while they had frame on. This was because of health and safety regulations as their job involve food preparation or work in a nursing home. Only 1 patient said it was too painful to work hence returned to work after removal of frame.

Discussion

Management of the pilon fractures of base of middle phalanx is a challenging problem. A wide range of treatment options are available with variable results. Residual pain and stiffness remains the major issues following these types of injuries. Splintage only has been shown to be associated with poor outcomes [5]. Open reduction and internal fixation is technically demanding and frequently impossible due to comminution of fragments. Although it may restore anatomical configuration of the joint, however infection and stiffness are considerable risks [14–16]. Early mobilization after

surgery is essential to improve the outcomes hence dynamic external fixator has many advantages in treatment of these fractures [17]. First, it can provides distraction across the PIP joint, which takes load off the articular fragments, thereby allowing them to heal without a deforming force. Second, traction across the joint and soft tissue can reduce fracture fragments through ligamentotaxis. Third, early active and passive range of movements allowed by this fixator prevents contractures or adhesions of the collateral ligaments, volar plate, and tendons. Continuous passive motion itself has been shown to help cartilage healing by supplying nutrition to and removing waste products from the joints [18]. Finally, external fixation avoids the trauma of extensive open surgery, which may exacerbate stiffness and yet not accomplish the goal of stable reduction of the fracture fragments. This is especially true when considerable comminution is present.

Different techniques have been devised to apply ligamentotaxis and allow early joint motion with variable results. Schenck [11] described a unidirectional longitudinal skeletal traction splints to provide passive movements at regular intervals. Other splinting techniques used include extension blocking splints, Agee's Force Couple Splint [7], and S-Quattro splint [8] with some studies reporting good results (average arc of motion 87°). However, these were not all successful and have been associated with long-term pain, degenerative arthritis and restricted joint motion. Furthermore, these splints are cumbersome for the patients especially when dressing and sleeping.

There has been an increasing trend in the use of external fixator over the last two decades and a range of external fixation devices with different levels of complexity have been devised. This includes Mini phalangeal distracter,

Table 1 Detailed data of all participants

Age	Sex	Finger involved	Treatment delay-days	Follow-up weeks	ROM degrees	Pain	Return to work- days	Satisfaction score
70	F	R-little	4	42	10–90	0	NA	10
52	M	L-thumb	14	28	0–65	0	NA	10
26	M	L- ring	5	14	12–95	1	1	9
39	F	L-little	2	12	15–82	0	3	10
21	M	R-ring	8	12	15–110	2	12	9
53	F	R-ring	3	12	15–90	0	38	10
38	M	R-middle	5	12	0–90	0	1	10
45	F	R-little	4	12	35–90	0	40	9
28	M	R-ring	6	12	10–85	0	1	9
41	F	R-little	4	12	20–85	0	8	10
22	M	L-ring	19	12	20–75	2	42 ^a	6
22	M	R-ring	9	lost	to	follow up		-

Key; visual analogue pain scale, score from 0 to 10, 0-no pain and 10 worse pain ever

Satisfaction scale key; score from 0 to 10, 0 mean very dissatisfied and 10 mean very satisfied

Return to work in italics – not allowed to attend work by employer

^a Too painful for patient to work

Table 2 Comparison of published studies

Study	n	Type of fractures	Method used	Delay in surgery	AOM ^a	Early complication rate
Lee	12	Dorsal fracture dislocation	ORIF (mini screw)	9.2 days	85	Not mentioned
Hamilton	9	Volar lip #- unstable dorsal fracture dislocation	ORIF Mini screw	17 days	70	Average flexion contracture 14° Increase complication with > 1 fragment, 2 cases pain on heavy activity, no infection, 1 case intra-articular screw penetration
Krakauer (acute fractures)	12	2 volar fracture and 10 dorsal fracture dislocations	Compass PIP Hinge + some other	< 14 days	9–82 ^b	Pain –3, Recurrent subluxation –3, Pin track infection-1
Johnson	15	Mixed variety of #, at PIP and DIP	Spring DEF	days to weeks	6–74 ^b	Infection –2, Additional fixation –1 Re-adjustment of fixator –2
Inanami	7	# dislocation of PIP	DEF	13.7 days	87.5	No infection, Mild pain-1, Subluxation –1
Ruland	34	Pilon # 8 # dislocation 26	DEF	30 days	88 5–93 ^b	8 cases (29 %) pin track infection rate, 1 extensor mechanism adhesion, 1 swan-neck deformity
Ellis	8	Mixed # dislocation and Pilon type #	Pin & rubber band DEF	5.8 days	1–89 ^b	1 Pin site infection, 2 ulnar deformity
Hynes	8	Pilon #	DEF	10 days	12–88	2 cases pin site infection, mild pain 3
our study	12	Pilon #	DEF	7 days	13–87	Pin site infection-1, Mild pain –3

^a AOM arc of motion, ^b total range of movement

Inanami's external fixator, Suzuki frame, and Compass hinge [9, 12, 19, 20]. A comparison study showed nearly similar outcomes by most of them with average achieved arc of movements from 10 to 90°. There was no extra benefit found with more complex fixator and all were associated with variety of complications [21]. Most of these studies include all fracture dislocations while the DDEF used in our study was originally designed [13] and used in this study for Pilon type of fractures.

Reviews comparing the results of the ORIF and less invasive techniques suggest that the benefits achieved by anatomic reduction may not warrant the risk of open procedure [15]. Stern et al. [5] compared groups of patients who were treated with splinting, ORIF, and dynamic skeletal traction. Comparable results were seen with ORIF and dynamic skeletal traction averaging between 80 and 90° of flexion while splinting only had poor outcome. A spring external fixator has been reported to achieve 95-degree PIP movement in acute cases and 80° in chronic patients with no pin site infection or non-union [9]. However, they included all fractures that needed surgical intervention, not just the Pilon ones. Similarly, Johnson et al. [6] using a modified Allison's fixator reproduces excellent ranges of movements in majority of cases and no major complications. Table 2 shows the comparison of some of the published studies.

Literature review suggests that external fixator is a good option for treatment of these fractures [14, 16, 17, 22]. Our findings were consistent with the above studies. We believe these complex fractures can be successfully treated with DDEF and its results are reproducible. We used the construct in reverse to the original description by Hynes and Giddins

[13] and we feel this may reduce the risk of infection by avoiding movement at wire-bone interface in the proximal phalanx. In the original study there were 2 pin-site infections in 8 cases, while in our series we had one pin-site infection in 12 cases. Our numbers of cases are too small to make any meaningful statistical conclusion; however, other studies have supported this theory [16].

DDEF is a relatively simple device, using widely available equipment (1.1 mm K-Wire) and is compact, thus allowing more than one finger to be treated at same time. It maintains reduction and restores digital range of motion. Early return to work, good pain relief and high level of patient's satisfaction was achieved. Our short term results are comparable to best previously published results. Based on our experience we recommend this technique of DDEF to treat these complex intra-articular fractures of base of middle phalanx involving the PIP joints.

Conflict Interest All named authors hereby declare that they have no conflicts of interest to disclose.

References

1. Bostock S, Fahmy NR, Nee P (1993) The 'S' Quattro—results of treatment in 11 cases of sports injury. *Br J Sports Med* 27:268–270
2. Zemel NP, Stark HH (1988) Problem fractures and dislocations of the hand. *Instr Course Lect* 37:235–249
3. Bain GI, Mehta JA, Heptinstall RJ, Bria M (1998) Dynamic external fixation for injuries of the proximal interphalangeal joint. *J Bone Joint Surg Br* 80:1014–1019

4. Lee JY, Teoh LC (2006) Dorsal fracture dislocations of the proximal interphalangeal joint treated by open reduction and interfragmentary screw fixation: indications, approaches and results. *J Hand Surg Br* 31:138–146
5. Stern PJ, Roman RJ, Kieffhaber TR, McDonough JJ (1991) Pilon fractures of the proximal interphalangeal joint. *J Hand Surg Am* 16:844–850
6. Johnson D, Tiernan E, Richards AM, Cole RP (2004) Dynamic external fixation for complex intra-articular phalangeal fractures. *J Hand Surg Br* 29:76–81
7. Agee JM (1987) Unstable fracture dislocations of the proximal interphalangeal joint. Treatment with the force couple splint. *Clin Orthop Relat Res* 214:101–112
8. Fahmy NR, Harvey RA (1992) The “S” Quattro in the management of fractures in the hand. *J Hand Surg Br* 17:321–331
9. Inanami H, Ninomiya S, Okutsu I, Tarui T (1993) Dynamic external finger fixator for fracture dislocation of the proximal interphalangeal joint. *J Hand Surg Am* 18:160–164
10. Khan W, Fahmy N (2006) The S-Quattro in the management of acute intraarticular phalangeal fractures of the hand. *J Hand Surg Br* 31:79–92
11. Schenck RR (1986) Dynamic traction and early passive movement for fractures of the proximal interphalangeal joint. *J Hand Surg Am* 11:850–858
12. Suzuki Y, Matsunaga T, Sato S, Yokoi T (1994) The pins and rubbers traction system for treatment of comminuted intraarticular fractures and fracture-dislocations in the hand. *J Hand Surg Br* 19:98–107
13. Hynes MC, Giddins GE (2001) Dynamic external fixation for pilon fractures of the interphalangeal joints. *J Hand Surg Br* 26:122–124
14. Aladin A, Davis TR (2005) Dorsal fracture-dislocation of the proximal interphalangeal joint: a comparative study of percutaneous Kirschner wire fixation versus open reduction and internal fixation. *J Hand Surg Br* 30:120–128
15. Ruland RT, Hogan CJ, Cannon DL, Slade JF (2008) Use of dynamic distraction external fixation for unstable fracture-dislocations of the proximal interphalangeal joint. *J Hand Surg Am* 33:19–25
16. Syed AA, Agarwal M, Boome R (2003) Dynamic external fixator for pilon fractures of the proximal interphalangeal joints: a simple fixator for a complex fracture. *J Hand Surg Br* 28:137–141
17. Ellis SJ, Cheng R, Prokopoulos P, Chetboun A, Wolfe SW, Athanasian EA, Weiland AJ (2007) Treatment of proximal interphalangeal dorsal fracture-dislocation injuries with dynamic external fixation: a pins and rubber band system. *J Hand Surg Am* 32:1242–1250
18. Salter RB (1994) The physiologic basis of continuous passive motion for articular cartilage healing and regeneration. *Hand Clin* 10:211–219
19. Hastings H 2nd, Ernst JM (1993) Dynamic external fixation for fractures of the proximal interphalangeal joint. *Hand Clin* 9:659–674
20. Patel MR, Joshi BB (1994) Distraction method for chronic dorsal fracture dislocation of the proximal interphalangeal joint. *Hand Clin* 10:327–337
21. Krakauer JD, Stern PJ (1996) Hinged device for fractures involving the proximal interphalangeal joint. *Clin Orthop Relat Res* 327:29–37
22. Badia A, Riano F, Ravikoff J, Khouri R, Gonzalez-Hernandez E, Orbay JL (2005) Dynamic intradigital external fixation for proximal interphalangeal joint fracture dislocations. *J Hand Surg Am* 30:154–160