Pain, stiffness, instability and degenerative arthritis are common sequelae of complex fracture-dislocations of the proximal interphalangeal (PIP) joint. Operations were carried out to obtain stability, followed by application of a dynamic external fixator in 20 patients with a mean age of 29 years. This provided stability and distraction, and allowed controlled passive movement. Most (70%) of the patients had a chronic lesion and the mean time from injury to surgery was 215 days (3 to 1953). The final mean range of movement was 12 to 86°.

Complications included redislocation and septic arthritis, which affected the outcome. Four pin-track infections and two breakages of the hinge did not influence the result. The PIP Compass hinge is a useful adjunct to surgical reconstruction of the injured PIP joint.

Injuries to the proximal interphalangeal (PIP) joint of the finger are common in ball sports. They are caused by hyperextension and axial loading which result in impaction of the volar articular surface of the middle phalanx against the condyles of the proximal phalanx. The damage varies from a sprain of the collateral ligaments to a complex comminuted fracture-dislocation.

There is a wide range of options for treatment. Early mobilisation after surgery or operation improves the outcome. The value of distraction has also been reported by many authors.

We describe a method in which controlled passive and protected mobilisation was used with a dynamic external fixator.

Patients and Methods

The Compass hinge (Smith & Nephew Richards, Memphis, Tennessee) is applied after primary reconstruction to allow early controlled and protected movement of the PIP joint. It is a radiolucent unilateral hinged external fixator, which maintains stability of the joint and has a worm gear to provide controlled passive movement. This gear can be disengaged to allow active mobilisation. Distraction can be applied across the joint.

We reviewed 20 patients in whom the Compass hinge had been applied by the senior author (GIB) between November 1994 and September 1996. There were fracture dislocations of the PIP joint in ten patients, a dorsal dislocation of the PIP joint in two, PIP joint contracture in two, fractures of the base of the middle phalanx in one, a fracture of the head of the proximal phalanx in one and swan-neck deformities after longstanding avulsions of the volar plate in four (Table I).

In each of these patients, the PIP joint was reconstructed by arthroplasty or internal fixation, and the final mean range of movement was 12 to 86°.

Details of the patients are shown in Table I. Nine (mean age, 26 years) were treated by a volar plate arthroplasty (average delay from injury to surgery, 423 days). The remaining 11 (mean age, 28 years) had open reduction and internal fixation of fractures of the PIP joint (average delay from injury to surgery, 27 days).

Operative technique. We performed open reduction and internal fixation using small Kirschner (K-) wires or a cerclage suture (Fig. 1). Dorsal dislocations, with or without a fracture, were approached using a Bruner or lateral...
Table I. Details of the 20 patients with PIP joint injuries

<table>
<thead>
<tr>
<th>Case</th>
<th>Age (yr)</th>
<th>Duration of surgery (days)</th>
<th>Injured digit</th>
<th>Injury*</th>
<th>Type of treatment</th>
<th>Duration of immobilization (days)</th>
<th>Final range of motion (degrees)</th>
<th>Effective range of motion (degrees)</th>
<th>Complications</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>19</td>
<td>20</td>
<td>Right little</td>
<td>Fracture base</td>
<td>MP and dislocation</td>
<td>ORIF</td>
<td>49</td>
<td>0 to 70</td>
<td>70</td>
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<tr>
<td>2</td>
<td>25</td>
<td>31</td>
<td>Left little</td>
<td>Fracture base</td>
<td>MP and dislocation</td>
<td>ORIF</td>
<td>31</td>
<td>+45 to 65</td>
<td>20</td>
</tr>
<tr>
<td>3</td>
<td>40</td>
<td>42</td>
<td>Left index</td>
<td>Fracture base</td>
<td>MP and dislocation</td>
<td>ORIF</td>
<td>42</td>
<td>0 to 85</td>
<td>75</td>
</tr>
<tr>
<td>4</td>
<td>53</td>
<td>53</td>
<td>Right index</td>
<td>PIP joint</td>
<td>Flexion contracture</td>
<td>ORIF</td>
<td>53</td>
<td>+30 to 60</td>
<td>30</td>
</tr>
<tr>
<td>5</td>
<td>42</td>
<td>48</td>
<td>Right ring</td>
<td>Fracture base</td>
<td>MP and dislocation</td>
<td>ORIF</td>
<td>48</td>
<td>0 to 105</td>
<td>105</td>
</tr>
<tr>
<td>6</td>
<td>21</td>
<td>14</td>
<td>Left ring</td>
<td>Fracture head</td>
<td>PP</td>
<td>ORIF</td>
<td>14</td>
<td>+25 to 105</td>
<td>80</td>
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<tr>
<td>7</td>
<td>29</td>
<td>64</td>
<td>Left middle</td>
<td>Chronic dorsal</td>
<td>Dislocation PIP joint</td>
<td>VPA</td>
<td>64</td>
<td>0 to 76</td>
<td>76</td>
</tr>
<tr>
<td>8</td>
<td>21</td>
<td>46</td>
<td>Right ring</td>
<td>Fracture base</td>
<td>MP and dislocation</td>
<td>VPA</td>
<td>46</td>
<td>+36 to 90</td>
<td>55</td>
</tr>
<tr>
<td>9</td>
<td>42</td>
<td>42</td>
<td>Right little</td>
<td>Swan-neck deformity</td>
<td></td>
<td>VPA</td>
<td>42</td>
<td>0 to 95</td>
<td>95</td>
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<tr>
<td>10</td>
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<td>13</td>
<td>Right ring</td>
<td>Swan-neck deformity</td>
<td></td>
<td>VPA</td>
<td>13</td>
<td>0 to 100</td>
<td>100</td>
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<tr>
<td>11</td>
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<td>11</td>
<td>Left little</td>
<td>Fracture base</td>
<td>MP</td>
<td>ORIF</td>
<td>11</td>
<td>+5 to 105</td>
<td>100</td>
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<tr>
<td>12</td>
<td>55</td>
<td>3</td>
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<td>Fracture base</td>
<td>MP with dislocation</td>
<td>ORIF</td>
<td>3</td>
<td>0 to 60</td>
<td>60</td>
</tr>
<tr>
<td>13</td>
<td>27</td>
<td>91</td>
<td>Right little</td>
<td>Chronic dorsal</td>
<td>Dislocation VPA</td>
<td>VPA</td>
<td>91</td>
<td>+15 to 60</td>
<td>45</td>
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<tr>
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<td>Left index</td>
<td>Fracture base</td>
<td>MP and dislocation</td>
<td>ORIF</td>
<td>17</td>
<td>+15 to 85</td>
<td>70</td>
</tr>
<tr>
<td>15</td>
<td>28</td>
<td>3</td>
<td>Right ring</td>
<td>Fracture base</td>
<td>MP and dislocation</td>
<td>ORIF</td>
<td>3</td>
<td>+15 to 105</td>
<td>90</td>
</tr>
<tr>
<td>16</td>
<td>31</td>
<td>1953</td>
<td>Left ring</td>
<td>Swan-neck deformity</td>
<td></td>
<td>VPA</td>
<td>1953</td>
<td>+5 to 115</td>
<td>110</td>
</tr>
<tr>
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<td>21</td>
<td>730</td>
<td>Left little</td>
<td>Swan-neck deformity</td>
<td></td>
<td>VPA</td>
<td>730</td>
<td>+5 to 95</td>
<td>90</td>
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<tr>
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<td>26</td>
<td>4</td>
<td>Right ring</td>
<td>Fracture base</td>
<td>MP and dislocation</td>
<td>VPA</td>
<td>4</td>
<td>+10 to 85</td>
<td>75</td>
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<tr>
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<td>26</td>
<td>60</td>
<td>Left ring</td>
<td>Fracture base</td>
<td>MP and dislocation</td>
<td>VPA</td>
<td>60</td>
<td>+20 to 90</td>
<td>65</td>
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<tr>
<td>20</td>
<td>28</td>
<td>23</td>
<td>Left ring</td>
<td>Fracture base</td>
<td>MP and dislocation</td>
<td>VPA</td>
<td>23</td>
<td>+20 to 90</td>
<td>65</td>
</tr>
</tbody>
</table>

Average follow-up: 226 days

* MP, middle phalanx; PP, proximal phalanx; FDS, flexor digitorum superficialis
† ORIF, open reduction and internal fixation; VPA, volar plate arthroplasty
incision. The A3 pulley was excised and the flexor tendons retracted on tapes to expose the volar plate. The collateral ligaments were released from the proximal phalanx. In the chronic cases the fibrofatty pulvinar was removed from beneath the extensor mechanism. The volar plate could be advanced after the check-rein ligaments had been released. The base of the middle phalanx was debrided; sutures were placed into the volar plate and advanced through the middle phalanx to the “bare area” just distal to the central slip. A transarticular K-wire was not used in any case.

Of the ten patients with dorsal fracture-dislocations, two had a fracture of the volar lip and an avulsion of the volar plate from the detached fragment producing a double or segmental injury to the volar buttress mechanism. The volar bony fragment was excised since it was likely to be avascular, and a volar plate arthroplasty was performed.

A K-wire was then advanced across the anatomical axis of the PIP joint at the centre of the head of the proximal phalanx to become the mechanical axis of the Compass hinge which was placed on to the axis pin. Two K-wires (1.143 mm) were inserted into each of the proximal and middle phalanges, the pin blocks tightened and distraction applied.

The joint was moved passively as far as possible through its range of movement and the reduction confirmed by fluoroscopy (Fig. 2). The lateral projection was closely scrutinised to ensure that subtle dorsal subluxation was not overlooked. The sutures in the volar plate were tied with the joint in 45° of flexion.

In complex cases stability could be improved by the placement of the mechanical axis pin in a more volar position which provides greater stability in extension, but not distally as the collateral ligaments would have become impaled. Other techniques which could be used to improve stability included volar translation of the base of the middle phalanx before tightening the pin blocks, leaving the axis pin in situ at the completion of the procedure, or prevention of mobilisation into extension in the early postoperative phase (Fig. 3).

Initially, all patients began controlled passive mobilisation with the worm gear on the first day after operation, (Fig. 4) but due to early infections we decided to delay mobilisation until five to seven days, when the swelling was resolving.

In patients with volar plate arthroplasties, extension was not allowed beyond 20° until the fourth postoperative week. At three to four weeks the worm gear was disengaged to allow active mobilisation and the patients then aimed for the maximum active and passive range before removal of the hinge.

The fixator was removed under local anaesthesia in the outpatient clinic and physiotherapy continued. The patients were reviewed at least six months after operation by a research physiotherapist and the active range of movement measured by a goniometer (Fig. 5).

**Results**

The hinge was well tolerated. It was in place for an average of 42 days. The mean final range of active movement was 12 to 86°. In patients with acute injuries (<2 weeks) it was 14 to 84° and in those patients with chronic injuries (>2 weeks) 12 to 87° (Table I).

The mean final range of active movement in the nine patients who had volar plate arthroplasty was 11 to 90° and in the 11 patients with open reduction and internal fixation it was 13 to 82°.

**Complications.** One patient developed a wound infection
with septic arthritis which ultimately resulted in an arthrodesis. Four others developed pin-track infections, which were successfully treated with antibiotics. One patient, six months after a dislocation, had advancement of the volar plate and application of the Compass hinge. The joint redislocated one week after removal of the hinge. Two patients had breakage of the pin block with no significant sequelae.

**Discussion**

Distraction utilises Vidal’s principle of ligamentotaxis to provide reduction, and has been reported to provide good results by many authors.\(^{12,21,22,24-27}\) Schenck\(^{12,22}\) advocated unidirectional longitudinal skeletal traction attached to a forearm-based arcuate splint with a rubber band. Such ‘Banjo-style’ splints are difficult to construct and cumbersome for the patient, especially when dressing and sleeping. A number of less complicated distraction techniques have recently been developed.\(^{18,27}\) Patel and Joshi\(^{25}\) reported use of the mini-phalangeal distractor, which is based on the Ilizarov principle of gradual fractional distraction, for chronic lesions with soft-tissue contractures. Agee\(^{4}\) developed the ‘force couple splint’, which utilises phalangeal K-wires to provide a volar reduction force on the base of the middle phalanx. This technique does not provide traction, and cannot be used for comminuted fractures with loss of the dorsal buttress.

The rhomboid bilateral spring-loaded external fixator, developed by Inanami et al.,\(^{8}\) provides distraction and places a volar directed force on the base of the middle phalanx to maintain reduction of the PIP joint. Hastings and
Carroll and Hastings and Ernst reported the use of a bilateral external fixator which has a pin at the anatomical axis of the proximal phalanx and two pins in the middle phalanx. This fixator provides distraction and allows some correction of the instability, while giving isometric mobilisation.

The Compass hinge differs from other devices in that it provides distraction, stabilisation, and controlled passive mobilisation. The worm gear, when engaged, allows the finger to be passively flexed and, when disengaged, makes active movement possible. It is controlled by the patient and allows the joint to move with a mechanical advantage similar to that of a turnbuckle splint, commonly used in the elbow. The angular markings on the hinge allowed the patients to monitor their recovery and to set goals with the hand therapist. It can also be used within a limited range of movement if the joint is unstable or to allow the volar plate arthroplasty to heal. Alternatively, the hinge can be held in extension to minimise the risk of fixed flexion deformity.

Our series, and those reported by Hotchkiss, and Krakauer and Stern, largely consisted of patients who had a delayed presentation for specialised management of complex injuries. This is in contrast to studies reported by other authors. Krakauer and Stern used the PIP Compass hinge in conjunction with a range of other procedures in 20 patients. The mean active range in the 12 acute cases treated within two weeks was 9 to 82°, and in the eight chronic cases 21 to 77°. The complications included two pin-track infections, one deep infection, one loose implant, four recurrent subluxations and resorption of the head of the proximal phalanx in one patient.

Hotchkiss, who developed the Compass hinge, reported 20 cases of which five were acute. The average active range of movement in these five patients was 16 to 91° and in the 12 chronic cases 12 to 89°. All patients had concomitant open procedures. Distraction interposition arthroplasty was attempted as a salvage procedure in three patients, but failed. Pin-track infection developed in 12 patients; two had failure of the fixator block and three showed gross loosening of the pins.

In our series the mean active range was 14 to 84° in the six acute cases and 12 to 87° in the 14 chronic injuries. The mean functional range in the normal PIP joint of the finger is 23 to 87°. Infection has been a significant problem in a number of studies using external fixators and was reported to be up to 60% by Hotchkiss. We reduced the incidence of infection by delaying mobilisation. We recommend that movement is started only after the initial stage of the acute inflammatory phase has subsided.

Residual instability has been a significant complication for a number of authors, including Krakauer and Stern who described five cases and Hotchkiss who reported three. There was one redislocation after the hinge was removed in a patient with a six-month-old dislocation treated by a volar plate arthroplasty. We believe that this was a failure of fixation or healing and not due to the fixator. We recommend that stability be obtained with an open reconstructive procedure and that the Compass hinge be used to maintain this.

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.

References


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