Complex fracture-dislocation of the proximal interphalangeal joint of the hand

RESULTS OF A MODIFIED PINS AND RUBBERS TRACTION SYSTEM

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We reviewed 13 patients with a complex fracture-dislocation of the proximal interphalangeal joint of a finger and one patient with a complex fracture-dislocation of the interphalangeal joint of thumb. We had treated these injuries using a pins and rubbers traction system which had been modified to avoid friction of the pins against the bone during mobilisation of the joint in order to minimise the risk of osteolysis. A Michigan hand outcome questionnaire was used for subjective assessment. The active range of movement (AROM) of the proximal and distal interphalangeal joints and the grip strength were used for objective assessment.

The mean follow-up was 34 months (12 to 49). The mean normalised Michigan hand outcome score was 84. The mean AROM of the proximal interphalangeal joint was 85° and that of the distal interphalangeal joint 48°. The mean grip strength was 92% of the uninvolved hand.

Twelve patients have returned to their original occupations. There has been no radiological osteolysis or clinical osteomyelitis. This modified traction system has given acceptable results with a low rate of complications. It is light, cheap, effective and easy to apply.

Fracture-dislocation of the proximal interphalangeal (PIP) joint of the hand, although relatively uncommon, is a potentially disabling injury which leads to persistent pain and stiffness.1-3

The management of unstable fracture-dislocations which involve the PIP joint is still a formidable dilemma. Immobilisation after closed reduction invariably leads to stiffness.4 Early mobilisation is desirable, not only to avoid stiffness but also to help the damaged articular cartilage to regenerate.5 The results of open reduction and internal fixation have not been encouraging since considerable periarticular soft-tissue stripping is required to achieve accurate reduction. This may cause stiffness of the joint.6 Moreover, in many cases anatomical restoration may be impossible because of excessive intra-articular and subchondral comminution.6

A traction device which can maintain satisfactory alignment of the fracture and reduction of the congruous joint, while allowing early active mobilisation, would seem to be an ideal goal in most cases of fracture-dislocation of the PIP joint.4,7 Various methods of treatment have been described in the literature.1-4,6-18 The pins and rubbers traction system (PRTS) of Suzuki et al16 (Fig. 1a) was modified (Fig. 1b) to address the problems associated with the axial traction pin site and was used to treat complex fracture-dislocations of the PIP joint of the fingers and the interphalangeal (IP) joint of the thumb. We now describe the technique and present the results for 14 patients with a minimum follow-up of 12 months.

Patients and Methods
Thirteen adult patients with a fracture-dislocation of the PIP joint of a finger and one with a fracture-dislocation of the IP joint of the thumb underwent treatment using a modified PRTS. There were two open and 12 closed injuries. Twelve had fractures of the base of the middle phalanx, one a T-Y condylar fracture of the proximal phalanx and one a fracture of the base of the distal phalanx of the thumb. We used the classification of Seno et al19 to classify the fractures of the base of the phalanx (Fig. 2; Table I). The fracture of the base of the distal phalanx of the thumb with volar subluxation was similar to a Seno type-3 fracture.

There were 11 men and three women with a mean age of 37 years (18 to 57). Seven injured their dominant hand. The methods of injury and the finger involved are shown in Table II.
The senior author (SCD) modified the PRTS of Suzuki et al\textsuperscript{16} (Fig. 1) so that a Kirschner (K-) wire is passed through the proximal phalanx as a counter-traction pin, parallel to the PIP joint line at the level of the origin of the collateral ligaments. These are marked by small elevations on either side of the neck of the proximal phalanx on an antero-posterior radiograph. A second K-wire, the hook pin, is passed through the distal part of the middle phalanx, parallel to the distal interphalangeal (DIP) joint and its ends are bent just outside the skin in the shape of a hook. Sterile aluminium wires 1.5 mm thick, forms the side-arms of the traction device. These extend at least 2.5 cm distal to the tip of the finger and clear the sides of the finger by at least 2 mm. The middle part is prepared with a small wire bender to create two troughs. The ends are next bent into loops through which the counter-traction pin is threaded on either side of the finger. The ends of the counter-traction pin are then turned over in order to form small loops. In the absence of subluxation or dislocation in the sagittal plane, the sidearms may be passed either dorsal or palmar to the hook pin. Rubbers are attached to both sides of the hook pin and looped over the troughs in the traction wire. The tension in the rubbers is adjusted to obtain distraction of 1 mm of the PIP joint. For pilon fractures without subluxation the aim is to achieve alignment of the articular surface in the anteroposterior and lateral planes, not an anatomical restoration of all the fracture fragments. For those with persistent subluxation in the sagittal plane, a third K-wire (reduction pin) is passed through the middle phalanx just distal to the site of the fracture, proximal to the hook pin, with the PIP joint held manually reduced with the traction system \textit{in situ}. It is imperative to pass this pin volar to the traction wire in the presence of persistent dorsal subluxa-

\begin{table}[h]
\centering
\caption{Fractures of the PIP joint in 13 patients}
\begin{tabular}{|c|c|c|c|c|c|}
\hline
\textbf{Location and classification of fractures} & \textbf{Number of fractures} \\
\hline
Base of the middle phalanx & & & & & \\
Seno type 1 & 3 & & & & \\
Seno type 2 & 2 & & & & \\
Seno type 3 & 6 & & & & \\
Seno type 4 & 0 & & & & \\
Seno type 5 & 1 & & & & \\
Head of the proximal phalanx & & & & & \\
T-Y fracture & 1 & & & & \\
\hline
\end{tabular}
\end{table}

\begin{table}[h]
\centering
\caption{Methods of injury and the finger involved (number of patients)}
\begin{tabular}{|c|c|c|c|c|c|}
\hline
\textbf{Method of injury} & \textbf{Thumb} & \textbf{Index} & \textbf{Middle} & \textbf{Ring} & \textbf{Little} \\
\hline
Sports & & & & & \\
Football & 1 & 1 & 2 & 4 & \\
Ski-ing & & & & & 1 \\
Road-traffic accident & 1 & 1 & 1 & 3 & \\
Fall & 2 & 1 & 3 & & \\
Hit by an object & 1 & 1 & 2 & & \\
Door handle & 1 & 1 & & & \\
\hline
Total & 1 & 0 & 2 & 6 & 5 \\
\hline
\end{tabular}
\end{table}
tion and dorsal to the traction wire in the presence of persistent volar subluxation. Immediate active and passive mobilisation of all fingers is encouraged from the day after surgery (Fig. 3).

All operations were performed by the senior author (SCD). The patients were followed up clinically and radiologically at weekly intervals until the traction system was removed, usually three to five weeks after application. After the operation, the patients underwent regular physiotherapy with the traction system in place and for three to six weeks after it was removed. They were followed up subsequently at six weeks and then at three and six months thereafter.

All the patients were reviewed by one surgeon (DK) who had not been involved in the surgical procedure. The Michigan hand outcome questionnaire was used to assess the
subjective results at the latest follow-up. For an objective assessment of the results, the active range of movement (AROM) of the PIP and DIP joints of the injured finger and the same finger of the uninjured hand were recorded. The grip strength in both hands was also measured.

**Statistical analysis.** The Pearson correlation test was used to establish if there was any significant relationship between either the time from injury to operation, or the age of the patient and the outcome of treatment. P values of less than 0.05 were regarded as significant.

**Results**

The mean period of follow-up was 34 months (12 to 49). Two patients chose to be followed up by telephone after one year of treatment.

There was a mean delay of 4.5 days (1 to 22) between injury and surgery. The traction system was maintained for a mean of three weeks (2 to 4). Adjustment of the rubber tension during the weekly follow-up was required for three patients in order to improve a deteriorated position of the fracture (Fig. 4). The mean normalised Michigan hand outcome score for the injured hand was 84 (33 to 100). The mean AROM of the injured PIP joints was 85˚ (60 to 105) and of the DIP joints (including the IP joint of the thumb) was 48˚ (10 to 90). The mean grip strength of the injured hand was 92% (70 to 113) of the strength of the uninjured hand. Twelve patients have since returned to their original jobs.

The time from injury to operation correlated negatively with both the AROM of the PIP joint \((r = -0.85, p < 0.001)\) and the normalised Michigan hand outcome score \((r = -0.85, p < 0.001)\). There was also a negative correlation between the time from injury to operation and the grip strength, but this was not statistically significant \((r = -0.476, p = 0.086)\). No significant correlation was found between the age of the patient and the outcome \((r = 0.05, p = 0.85\) for the Michigan hand outcome score; \(r = -0.25, p = 0.39\) for grip strength; and \(r = -0.311, p = 0.3\) for the AROM of the PIP joint).

**Complications.** Two patients developed a minor pin-track infection which did not require removal of the wire. They were treated with oral antibiotics. Two developed mild cold intolerance. Two fractures united in 10˚ of valgus and one in 10˚ of hyperextension. One fracture collapsed after removal of the traction system at three weeks. This led to 10˚ of radial angulation (Fig. 5). No patient developed osteomyelitis or osteitis and no patient has as yet sought treatment for persistent pain. Follow-up radiographs show remodelling of the base of the middle phalanx with varying degrees of splaying, mainly in the sagittal plane. At the final follow-up there was radiographic evidence of osteoarthritis in one patient (Fig. 3) who has not required further surgery to date.

**Discussion**

The management of intra-articular fractures of the PIP joint is a therapeutic problem. A transarticular K-wire has been...
used for stability after a closed or open reduction and after volar plate arthroplasty for both acute and chronic dorsal fracture-dislocations of the PIP joint.\textsuperscript{2,8,12,13,21,22} This technique prevents any movement of the joint for the initial two to three weeks after injury. In comminuted fractures of the PIP joint with small articular fragments, fixation by K-wires may not be applicable.\textsuperscript{2} They have also been used for extension-block splinting of the joint in dorsal fracture-dislocations of the PIP joint,\textsuperscript{23,24} but this can also be achieved non-invasively with extension-block splints.\textsuperscript{1,25} The importance of continuous movement in the healing of hyaline articular cartilage was established by Salter et al.\textsuperscript{5} Immobilisation of any joint interferes with the normal mechanisms of transport of synovial fluid and nutrition of the articular cartilage.\textsuperscript{26}

Stern et al\textsuperscript{6} compared the results of splinting, skeletal traction with early mobilisation, and open reduction and internal fixation for pilon fractures of the PIP joints. They concluded that open reduction and internal fixation can achieve anatomical reduction in some cases but should be approached cautiously. Excessive intra-articular and subchondral comminution can make anatomical reduction impossible and even unnecessary. Extensive soft-tissue dissection may deprive smaller fragments of their blood supply and contribute stiffness of the joint.\textsuperscript{6} Skeletal traction, combined with the movement provided by dynamic splints and traction systems, attempts to achieve and maintain the reduction by capsuloligamentotaxis. This gives results which are radiologically and clinically comparable with those obtained by open reduction and internal fixation.\textsuperscript{6}

The splint described by Schenck\textsuperscript{10} was unpopular since it was bulky and required the joint to be moved passively.\textsuperscript{17} That described by Agee\textsuperscript{4} (Fig. 6a) can only be used for dorsal fracture-dislocations and not for the reduction of articular comminution of pilon fractures because it does not provide capsuloligamentotaxis.\textsuperscript{17} The splints described by Inanami et al\textsuperscript{15} (Fig. 6b) and Allison\textsuperscript{7} (Fig. 6c) can reduce pilon fractures but the use of springs and a pulley in the former and the size of the ferrules in the latter can complicate these methods.\textsuperscript{17} The ‘S’ Quattro splint described by Fahmy\textsuperscript{16} (Fig. 6d) allows movement of the PIP joint but does not apply continuous elastic traction.\textsuperscript{16}

The PIP joint of any finger is not a simple hinge joint as described by Kuczynski,\textsuperscript{27} but has a few degrees of movement in the coronal and axial planes in addition to its predominant movement of flexion-extension.\textsuperscript{28-30} It also has instant centres of rotation.\textsuperscript{30} The PRTS of Suzuki et al\textsuperscript{16} respects this kinesiology whereas the traction system suggested by Hynes and Giddins\textsuperscript{18} (Fig. 6e) has a fixed distance between the two pins and allows for movement in only one plane.

Suzuki et al\textsuperscript{16} and De Soras et al\textsuperscript{17} reported excellent results with the use of a PRTS originally described by Suzuki et al\textsuperscript{16} for comminuted intra-articular fractures of the PIP joint. Differential tensioning in the rubbers in this system can be used to correct valgus or varus angulation of
the fracture intra-operatively and in the early post-operative period. In the case of a fracture-dislocation, the reduction pin is used as an additional stabiliser in order to maintain reduction during early post-operative mobilisation. However, De Soras et al. noted inflammation around the pin sites in up to 45% of cases. In their series there was one case of severe osteolysis around the traction pin which involved almost the whole of the head of the proximal phalanx (Fig. 7). The friction of movement at the bone-pin interface is probably the cause of osteolysis.

In our series, although two patients developed a superficial pin-site infection which was successfully treated by oral antibiotics, none developed osteitis or osteomyelitis which would have required earlier removal of the traction system. Our overall results, and the mean range of active flexion, compare favourably with those of other types of dynamic traction splint (Table III). We believe that this modified PRTS has the advantages of the PRTS of Suzuki et al but with the additional benefit of allowing movement between the side-arms and the counter traction pin. This avoids friction at the bone-pin interface. It also allows for correction of the position of fractures if there is any deterioration during follow-up, by altering the tension in the rubber bands. We believe that the capsuloligamentotaxis of a PRTS achieves reasonable articular congruity. However, in cases of severe condylar comminution it can leave a hollow beneath the subchondral bone. The articular fragment may collapse if the PRTS is removed before the healing of the fracture has filled this space (Fig. 5). We thus recommend that the traction should be left in place for two or three weeks longer than the usual three to five weeks for the more comminuted fractures. Alternatively, in cases of severe articular depression, supplementary bone grafting may be indicated and can be performed through a separate window away from the joint in order to avoid any periarticular dissection.

This modification of a pins and rubbers traction system has given very acceptable results with a low rate of complications. It is light, cheap, effective and easy to apply. Our results, however, have shown that there is a significant negative correlation between the time from injury to operation and the outcome of treatment. Inappropriate treatment is fraught with problems and a timely referral of these complex fracture-dislocations of PIP joints to appropriate centres can make the outcome more favourable. Furthermore, the contribution by vigilant and skilled hand therapists cannot be overestimated.

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References