FRACTURES OF THE BASE OF THE MIDDLE PHALANX OF THE FINGER
CLASSIFICATION, MANAGEMENT AND LONG-TERM RESULTS

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We classified fractures of the base of the middle phalanx into five types: 1) single palmar fragment; 2) single dorsal fragment; 3) two main fragments; 4) not involving the articular surface, including epiphyseal separation in children; and 5) all others. Types 1 and 2 were subclassified into avulsion, split and split-depression.

Surgery is recommended for unstable type-1 avulsion fractures, type-2 avulsions which may develop buttonhole deformities, and all fractures which displace articular cartilage surfaces. Long-term follow-up showed that surgical treatment which produced good stability and congruity gave good results. These should be the primary aims of treatment.

Received 6 February 1997; Accepted after revision 18 March 1997

Fractures of the base of the middle phalanx are usually intra-articular and often require surgical treatment. There are various patterns of injury in relation to the bony configuration and soft-tissue attachments. The type of fracture sustained depends on the strength and direction of the external stress, the site of stress concentration and the position of the joint. Systematic classification of these fractures is complex.

Many kinds of treatment are possible; the choice depends on the type of injury, and the long-term outcome must be assessed according to the type of fracture, because of the importance of remodelling and the late occurrence of osteoarthritic changes. There are few reports of long-term follow-up.

We have classified these fractures according to the mechanism of injury, and its pattern. We then reviewed our treatment strategy and studied our long-term results.

PATIENTS AND METHODS
From January 1981 to December 1990 we treated 135 patients with 140 fractures at the base of a middle phalanx. There were 93 males and 42 females with a mean age of 25.8 years (8 to 70). There were 89 right-sided fingers and 51 left-sided. The fingers involved were the index (26), middle (31), ring (35), and little (48).

The cause of injury was sport in 88 patients, which included stubbing the finger in a ball game in 72, falling while playing in 11, and physical combat in 5. In 15 the injury was due to simple stumbling, in 10 to stubbing and in 7 to catching the finger. Five patients had the finger twisted in a machine, and ten had other causes.

We classified the fractures into five types on the initial radiological and surgical findings (Figs 1 to 3). In type 1 the fracture was on the palmar side and in type 2 the bone fragments were on the dorsal side. Both these types were subclassified as: a) avulsion, b) split, or c) split-depression. Type 3 was the so-called pilon fracture, with the articular surface in two main fragments on the palmar and dorsal sides, neither in continuity with the shaft. Type-4 fractures did not cross the articular surface and were metaphyseal only. We included epiphyseal separation in young patients in this type. Type 5 included fractures which were not classifiable as 1 to 4, mainly those with sagittal splits.

Type-1b and type-1c fractures are the most severe due to axial stress and occurred mainly at softball (n = 15). This game uses a relatively small ball with a large mass; the larger balls used in basketball, dodge ball and volleyball usually caused type-1a injuries as a result of hyperextension or lateral deviation of the outstretched fingers.

Of the 140 fingers, 63 were treated surgically and 77 conservatively for the first two weeks after injury (Table I). We reviewed 56 of the 63 surgically-treated cases (87.5%).
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Type-1 fracture: a) avulsion, b) split, c) split-depression.

Type-2 fracture: a) avulsion, b) split, c) split-depression. The white arrow shows a split fragment and the small black arrows a central depressed fragment.

Type-3, type-4 and type-5 fractures: a) type 3, pilon fracture, b) type 4, c) type 5.

at a mean of 94 months (60 to 120), studying the clinical and radiological results.

The criteria used to record the clinical results in terms of movement, stability and pain are shown in Table II. Analysis of the radiological findings at follow-up recorded (Fig. 4): 1) incongruity of the bony middle phalangeal base to the proximal phalangeal head; 2) increase in the tilt angle of the joint line; 3) a change in depth; 4) a step-off in the joint surface of the phalangeal base; 5) widening of the base; and 6) degenerative changes at the base and head.

INDICATIONS AND OPERATIONS

The results in 77 fingers treated conservatively were generally good because most of these were stable type-1a fractures with small palmar fragments or type-4 injuries with minimal displacement or easy reduction.

Our type 1a included two degrees of injury, namely fractures with avulsion of the palmar plate without collateral ligament rupture caused by hyperextension and those with rupture of the collateral ligament caused by lateral deviation or torsion stress. We used surgery for fractures shown to be unstable by stress radiography on hyperextension or lateral stress. Ten of the 79 type-1a fractures had operations, five confirming injury of the collateral ligament. We used a lateral curved incision to expose both the collateral ligament and the attachments
the palmar plate, with Kirschner (K-) wire fixation for the so-called ‘corner’ fracture with relatively large bone fragments on either the radial or ulnar side. Pull-out fixation was used for fractures which involved the entire palmar margin.

Our type-2a fracture was considered to be a split fracture at the attachment of the central slip caused by a dorsal blow with avulsion by the extensor tendon. We operated when we considered that a buttonhole deformity would follow an injury to the central slip, using a dorsal curved incision. Fixation used a fine wire, a 0.7 mm K-wire or a mini screw depending on the size of the fragments.

Our type-1b, type-1c, type-2b and type-2c, split or split-depression fractures all had damage to the articular cartilage caused by axial stress, with dislocation or subluxation dorsally in types 1b and 1c, and in a palmar direction in types 2b and 2c. Types 1b and 1c with an oblique bone fragment on the palmar side, were unstable, often requiring open reduction of the bony fragment. This was especially true of type 1c with a central depressed fragment. We used a palmar curved incision; in some cases half of the attachment of flexor digitorum superficialis was cut to allow good exposure of the palmar split and the central depressed fragments. Reduction of the articular surface with bone grafts from the distal radius was often necessary to maintain the joint configuration. Pull-out wire fixation using fine wire achieved rigid fixation of the fragments. After bone grafting, the articular configuration was well preserved at follow-up (Fig. 5). The same principles applied to type-2b and type-2c injuries, in which bone fragments were produced on the dorsal side.

Operation was also indicated for type-3, type-4 and type-5 injuries which showed displacement of the articular surface.

RESULTS

The outcome of surgical treatment is related to fracture type in Table III. Our emphasis on achieving stability and conformity of the joint surfaces in these cases gave satisfactory results as regards these aspects, but the range of movement varied considerably. Type-1a and type-2 fractures showed comparatively good movement, but the ranges for type-1b, type-3 and type-5 fractures, all intra-articular, were poor. In our type-5 (unclassified) cases, the poor results were in those with a defect of the articular surface for which arthrodesis had been performed. Involvement or non-involvement of the articular cartilage surface was the main determinant of the prognosis for movement.

The radiological findings are related to the surgical
DISCUSSION

Fractures of the base of the middle phalanx have been classified as either dorsal or palmar fracture dislocations of the proximal interphalangeal (PIP) joint.\textsuperscript{16-19} The treatment strategy aims at complete reduction of the dislocation, but several anatomical structures may also need reconstruction. These include damage to the collateral ligament,\textsuperscript{2} the palmar plate\textsuperscript{20} or to the attachment of the central slip.\textsuperscript{18,19} Hastings and Carroll\textsuperscript{8} have classified fractures of the articular surface of the middle phalangeal base according to the pathological conditions. In our classification, based on need for treatment, types 1b and 1c correspond to dorsal fracture dislocations of the PIP joint\textsuperscript{16,17} and types 2b and 2c to palmar fracture dislocations.

The great variety of types of fracture is produced by the differing strength and direction of the injury force and the position of the interphalangeal joints at the time. We have used computer simulations to study this.\textsuperscript{6} An external force to the fingertip in its long axis, when the distal interphalangeal joint (DIP) is slightly flexed as in a swan-neck deformity, is transmitted to the PIP joint as shear on the palmar side of the middle phalangeal base, causing type-1b and type-1c fractures. Hyperextension of the DIP joint at the time of injury causes a buttonhole deformity position, with force transmitted dorsally at the PIP joint, causing type-2b and type-2c fractures. Types 2b and 2c are much less common, probably because force in the position of a buttonhole deformity requires both axial pressure and simultaneous pressure on the palmar aspect of the middle phalanx. Stubbing a finger against a ball, the main cause of such an injury, is much more likely with a finger in the position of a swan-neck rather than a buttonhole deformity.

Passive hyperextension is the cause of an avulsion fracture of the attachment of the palmar plate. Impaction of the articular surface with tension of the central slip of the extensor is the cause of an avulsion fracture of its attachment. Other soft tissues around the PIP joint are involved in

\begin{table}[h]
\centering
\begin{tabular}{|c|c|c|c|c|c|c|c|c|}
\hline
 & \textbf{Type 1} & & & \textbf{Type 2} & & & \textbf{Type} & \\
\cline{1-9}
 & \textbf{a} & \textbf{b} & \textbf{c} & \textbf{a} & \textbf{b} & \textbf{c} & \textbf{3} & \textbf{4} & \textbf{5} & \textbf{Total} \\
\hline
Excellent & 7 & 3 & 5 & 0 & 0 & 0 & 1 & 0 & 1 & 18 (32\%) \\
Good & 1 & 6 & 9 & 1 & 0 & 1 & 0 & 1 & 0 & 19 (34\%) \\
Fair & 2 & 0 & 6 & 0 & 0 & 0 & 1 & 1 & 0 & 10 (18\%) \\
Poor & 0 & 2 & 2 & 0 & 1 & 1 & 1 & 0 & 2 & 9 (16\%) \\
\hline
\end{tabular}
\caption{Results of surgical treatment at a mean of 94 months (60 to 120) related to the type of fracture (see text)}
\end{table}

\begin{table}[h]
\centering
\begin{tabular}{|c|c|c|c|c|c|c|c|c|c|}
\hline
\textbf{Results} & \textbf{Incongruity} & \textbf{Tilting} & \textbf{Depth} & \textbf{Step-off} & \textbf{Widening} & \textbf{OA change} \\
\hline
Excellent or good & -- & + & ++ & -- & + & ++ & -- & + & ++ & -- & + & ++ \\
Fair or poor & 0 & 7 & 12 & 0 & 10 & 9 & 0 & 4 & 15 & 8 & 6 & 5 & 4 & 5 & 10 & 0 & 4 & 15 \\
\hline
\end{tabular}
\caption{Radiological findings at a mean follow-up of 94 months (60 to 120), related to the clinical results of surgery}
\end{table}
various other types of fracture. 4,5,7

An anteriorly directed force on the dorsum with traction on the central slip produces a type-2a fracture and a longitudinal shearing force in a slightly flexed position a type-2b fracture. Axial loads which compress and shear the articular surface produce type-2c fractures.

Both conservative and surgical treatment aims to achieve and maintain complete reduction of the dislocation or subluxation and restore stability, sufficient to allow early movement. The extension-block technique 12,21,22 and skeletal traction 11,23 may be used to hold a reduced position, and advancement of the palmar plate in chronic cases also has this aim. 13 For the split and split-depression types of fracture (1b, 1c and 2b, 2c), open reduction of the joint surface and maintenance of a reduced position with bone graft are essential for good results. 3,24

The results of treatment need careful evaluation, since some remodelling can be expected, 13 which may improve the clinical outcome over three to four years. Evaluation of the results at five years after operation are necessary for the accurate assessment of methods of treatment. We found that a good reduced position persisted after surgery and a bone graft. By contrast, unsatisfactory reductions had deteriorated to a worse position at follow-up in a few cases. Inadequate joint conformity seemed to produce abnormal stress concentrations at the PIP joint, resulting in early degenerative changes.

A type-1a fracture, caused by hyperextension stress or dorsal dislocation of the PIP joint, will continue to give symptoms if left untreated or treated without lateral stabilisation. 20,25 It leads to swan-neck deformity, with loss of flexion of the PIP joint and snapping which may produce degenerative changes. Recurrent hyperextension and locking of the PIP joint 26 were widely recognised by Kaplan 27 to result from an untreated type-1a fracture. A residual bony defect of over 30% to 40% of the articular surface allows instability of the PIP joint. 8,13,28 This may also be seen if the fragment includes the collateral ligament and palmar plate attachments or is a central depression fragment of type-1c.

Type-2a fractures may occur with no PIP dislocation and should be recognised as due to disruption of the dynamic extensor mechanism; 19 treatment aims to avoid a button-hole deformity and restore joint congruity. 29

The central depression and central slip attachment fragments in type-2 injuries may also lead to instability. Type-2b and type-2c fractures are usually associated with palmar fracture dislocation of the PIP joint. 8,18,30 The serious and disabling soft-tissue injuries involved are not commonly recognised, often leading to casual or inadequate treatment. Again, treatment must restore full joint congruity and reduce any subluxation.

Type-3 fractures, pilon injuries, 15 are produced by axial impaction forces in a neutral position of the PIP joint. These are very unstable, because the same factors apply as in types 1 and 2.

Conclusions. The amount, direction and location of the causative force, the position of the PIP joint, and the tension of the intrinsic ligaments and extrinsic muscles determine the extent and type of fracture of the base of the middle phalanx. Prompt and accurate reduction of the displacement will produce satisfactory results. Open anatomical reduction of the articular surface, bone grafting, and internal fixation rigid enough to allow early mobilisation are sometimes needed to ensure a good outcome.

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


