REVIEW ARTICLE

FRACTURES OF THE HAND

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"Hand fractures can be complicated by deformity from no treatment, stiffness from overtreatment, and both deformity and stiffness from poor treatment" (Swanson 1970).

The management of fractures in the hand is a Cinderella subject, attracting little attention from either orthopaedic or hand surgeons. It is true that many patients will recover good function with little or no treatment; in fact some are actually made worse by treatment. It is therefore necessary to pick out, from the mass of patients with hand fractures, that minority of cases in which active steps are required, and to refrain from overtreating the others. Unfortunately, this is not what happens in all casualty departments and fracture clinics. All too often, no attempt is made to analyse what type of fracture is present or what the outcome is likely to be with and without immobilisation; instead the doctor reaches automatically for an aluminium splint, and then applies it incorrectly.

Table I. Classification of fractures of the phalanges

Type of fracture	Number	Percentage
Fingertip fractures	92	20.3
Epiphyseal fractures	130	28.7
Shaft fractures	109	24
Joint fractures	84	18.5
Comminuted fractures	39	8.6
Total	454	100

The first step is to decide what sort of fracture has been sustained, just as one would in the femur. Subcapital fractures are treated differently from shaft fractures. Even intra-articular fractures of the metacarpal head, which one might imagine to be a small and homogeneous group, have been divided into 10 different types, each presenting different problems (McElfresh and Dobyns 1983). As a cause of disability, phalangeal fractures are more important than metacarpal fractures, and a classi-

fication of fractures of the phalanges based on 454 patients studied personally is shown in Table I. Fractures of the shafts of the phalanges may be spiral, oblique or transverse; transverse fractures can be subdivided into those of the base, midshaft or neck of the phalanx. In each type, the management is different. It is not proposed to describe here the management of every type of fracture in the hand; this has been done elsewhere (Green and Rowland 1975; Sandzen 1979; Weeks 1981; Barton 1982). However, it is appropriate to consider the principles underlying treatment and how they may be applied.

Having identified the type of fracture, one must choose the method of treatment most appropriate for that particular fracture in that particular patient, based on the traditional three Rs of fracture treatment: reduction, retention and rehabilitation.

REDUCTION

Metacarpal fractures. These fractures are usually displaced or angulated, but (as with the clavicle) it is difficult to maintain reduction without undesirable side effects. The old method of treating fractures of the neck of the fifth metacarpal by strapping the finger in flexion has rightly been abandoned, because it sometimes produced irreversible flexion contractures of the interphalangeal joints which were more disabling than the deformity from the original fracture. Hunter and Cowen (1970) have shown that, in this type of fracture, considerable angulation is compatible with an early resumption of function. I treat these fractures simply with a crepe bandage, unless the angulation is more than 50°.

However, while angulation is often acceptable, it is essential to correct any rotational deformity whether in a phalanx or a metacarpal, as this can cause quite severe disability.

Reduction should also be attempted for Bennett's fracture-subluxation, though the late J. C. Griffiths (1964) showed that, even when the fracture was not properly reduced, surprisingly good functional results were achieved and that later osteoarthritis was rare; he concluded that it seemed doubtful whether the use of complex methods of treatment was justifiable. However, if correction of the subluxation can be achieved by simple means, then surely this should be done. Pollen (1968)

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0301-620X/84/2085 \$2.00

Fig. 1

Fig. 2

Figure 1—Fracture of shaft of proximal phalanx with the characteristic angulation concave dorsally. In this type of fracture, even a small amount of displacement must be corrected to avoid a step in the floor of the flexor sheath. Figure 2—Another fracture of the shaft of the proximal phalanx after reduction and immobilisation with an aluminium splint bent so that the metacarpophalangeal joint is flexed.

Fig. 3

Rotational malalignment of the ring finger after a fracture. This must be corrected, and the splintage must allow the fingers to be inspected end-on, like this, to make sure the rotation is correct.

reviewed 31 patients treated by manipulation and a carefully moulded plaster cast, as described by Charnley (1970); 29 were successfully treated in this way and operation was needed in only two, one in whom satisfactory reduction could not be achieved and one in whom the fracture was reduced but slipped afterwards.

Phalangeal fractures. About 75% of these fractures have little or no displacement, and reduction is therefore unnecessary. They can be treated perfectly satisfactorily by strapping the injured finger to an intact neighbouring finger and encouraging early movement. However, it is important not to throw out the baby with the bath water. In some types of phalangeal fracture, accurate reduction is very important. These include:

Fractures of the shaft of the proximal or middle phalanges, whose anterior surfaces form the floor of the flexor tendon

sheath (Fig. 1). If the fracture is not reduced, the tendon cannot be expected to glide normally (Lamphier 1957). Reduction is most easily accomplished with the metacarpophalangeal joint held flexed to stabilise the proximal fragment, and in this way it is often possible to achieve perfect reduction by closed manipulation (Fig. 2).

As with metacarpals, it is essential also to correct any rotational deformity which is, of course, particularly likely in spiral fractures. In order that rotation may be assessed, the tip of the finger must be visible after reduction and splintage so that the alignment of the fingernails seen end-on can be checked (Fig. 3). It is easy to correct malrotation of a fresh fracture, whereas later corrective osteotomy is a difficult operation.

Fractures of the base of the proximal phalanx present a different problem. Here, angulation is easily overlooked clinically because the fracture is near the metacarpophalangeal joint, and radiographically because the bones are superimposed in the lateral film, which is the view showing the deformity (Fig. 4). If these fractures are not reduced a deformity similar to clawing results (Coonrad and Pohlman 1969). This deformity is difficult to correct surgically but avoidable if the fracture is reduced in the first place; this is easy to do by simple manipulation, followed by immobilisation with the metacarpophalangeal joint flexed and the interphalangeal joints extended.

Fig. 4

Lateral radiograph showing 40° angulation of a fracture across the base of the proximal phalanx of the little finger. Note how overlap makes the deformity difficult to see.

Fractures of the neck of a phalanx often occur in children, and it is easy to assume that deformity will remodel with growth. However, the phalanges have a growth plate at only one end, and the fracture is at the other end: there is therefore no mechanism for remodelling and in practice it does not occur (Figs 5 to 8). Accurate reduction is thus required, and internal fixation may be necessary (Leonard and Dubravcik 1970).

Figures 5 and 6—Radiographs taken two weeks after a fracture of the neck of the proximal phalanx in a boy aged five years. The fracture was not reduced. Figures 7 and 8—The same finger five years later, showing persistence of the deformity not only in the lateral plane but also in the plane of flexion and extension, where it has caused a swan-neck deformity. Flexion of the proximal interphalangeal joint was markedly restricted.

Epiphyseal fractures (usually of the Salter-Harris Type 2) and fractures through the metaphysis are usually easy to reduce and it seems reasonable to try and manipulate the displaced fracture to restore normal alignment immediately. If this one attempt is not successful, further measures are not justifiable as remodelling will correct any deformity in almost all cases (Barton 1979b).

An exception to this is a fracture-separation of the base of the distal phalanx, which displaces dorsally through the nailbed and often through the skin also, so that it becomes a compound fracture. The first priority is thorough cleaning of the wound to try to prevent infection which unfortunately still often follows these injuries. Then a careful open reduction must be carried out, because the torn nailbed is interposed between the fragments and usually prevents closed reduction or later remodelling (Seymour 1966).

Articular fractures associated with any subluxation should be reduced. Fracture-subluxation of the proximal interphalangeal joint is usually a dorsal displacement of most of the middle phalanx, leaving a small anterior fragment behind. The subluxation can be reduced easily and is stable as long as the joint is kept flexed. It is, however, very undesirable to immobilise the proximal interphalangeal joint in much flexion, so various ingenious methods have been described to prevent full extension but allow free flexion (McElfresh, Dobyns and O'Brien 1972; Agee 1978).

If there is no subluxation and the fractured fragment is small, then reduction is not necessary. Lee (1963) has shown that even if they are appreciably displaced, fractures associated with mallet fingers will unite by

bone, and full active extension will be regained. However, if the fracture carries a large proportion of the articular surface it must be reduced; it cannot be held satisfactorily by conservative means and such fractures will therefore be considered under internal fixation.

RETENTION

Conservative treatment. Sir Reginald Watson-Jones, in his book on fractures, stated as the first principle of treatment of finger injuries that "the injured finger must be immobilised. No advantage is gained by refusing to immobilise a fracture, a dislocation, or a severe sprain of the finger. Stiffness of the joints will not be avoided in this way. Movement recovers more rapidly if the torn structures are immobilised and protected until the traumatic exudation has subsided" (Watson-Jones 1943).

His second principle was that the injured finger must be immobilised in flexion to avoid an extension contracture of the metacarpophalangeal joint. Koch of Chicago shared this concern: "the rapidity with which stiffness can develop at the joints of an immobilized hand is often one of the first lessons that the surgeon learns in the treatment of hand injuries. Too often when a surgeon has immobilized one or several fingers in extension because of a metacarpal or phalangeal fracture he finds to his dismay that the affected fingers are stiff in extension and that if he attempts gently to flex them they spring back into extension almost like a strip of spring steel" (Koch 1935). However Koch added that "an almost equally serious disability results if the fingers are allowed to remain indefinitely in the acutely flexed position" (a danger which Watson-Jones did not mention) and went

on to point out that "fixation at these joints is seen most commonly in one of two forms—fixation in extension at the metacarpophalangeal joints, and fixation in flexion at the proximal interphalangeal joints". He concluded that these contractures were "so common and so difficult of correction, once they have developed, that one cannot lay too great stress on their prevention following infection and injury by maintaining the immobilized hand in the position of function and by inaugurating active movement at the affected joints at the earliest possible moment."

metacarpophalangeal joints flexed and the interphalangeal joints extended. To put it another way, each joint is immobilised in the opposite position to that in which a contracture is likely to develop (James 1970). If only one finger is injured, this position can be maintained by a malleable aluminium splint. If such a splint is used, it is important that it is bent to 90° and attached to the hand with the bend at the level of the metacarpophalangeal joint (which is marked by the proximal and distal palmar creases, not the crease at the base of the finger which is halfway down the proximal phalanx). The splint should

Fig. 9

Fig. 10

Fig. 11

Figure 9—Position of rest. Figure 10—Position of immobilisation. Figure 11—Position of failure.

Koch did not specify what was meant by the "position of function" and it was left to James to define this. Indeed the term "position of function" is so variously used that it would be best to replace it by more precise terms, and in any case there is really no position of function: the hand functions by moving from one position to another. The *position of rest* (Fig. 9) is comfortable for the patient but if used for splintage is likely to result in permanent contractures. Each joint has an optimal *position for arthrodesis*, which if permanent will cause least disability. However, the *position of immobilisation* (Fig. 10), as James (1970) called it, is neither of these, but is comparable with the position in which you park your car if it has a faulty battery: it is left at the top of a hill from which position it will be easiest to get it moving again, even though you would not choose to leave it there permanently. In the hand, this position is with the

be applied to the volar surface of the finger only, leaving the tip uncovered so that it can be inspected end-on to check that the rotational position is correct. If more than one finger is fractured, the correct position is best retained by a volar plaster slab or, better still, separate volar and dorsal plaster slabs. Lastly, there is the *position of failure* or of contracture (Fig. 11), so vividly described by Koch and so disabling to the patient.

Watson-Jones' opinions, clearly and dogmatically expressed, held sway for 20 years, until challenged by James, who questioned not only the best position for immobilisation, but whether it was really necessary for every hand fracture. In the 1960s, 809 patients (280 with fractures of the metacarpals and 529 with phalangeal fractures) who had been treated in Edinburgh were reviewed by Wright (1968). He made a distinction between unstable injuries which must be immobilised

and stable fractures in which early movement gave better long-term results (Table II). He concluded that the hand must be mobilised early if normal function is to be regained, but if immobilisation is required, then it must be in the correct position. A similar conclusion was reached by Borgeskov (1967) who reviewed 485 fractures of the hand treated conservatively in Copenhagen; he found that it is important to avoid overtreatment and stressed the importance of early mobilisation.

Table II. Results of immobilisation for stable and unstable fractures

Period of immobilisation (weeks)	Percentage regaining full function	
	Stable fractures	Unstable fractures
None	81.0	—
1	74.5	76.9
2	76.4	69.4
3	49.7	66.7
4 or more	25.0	10.0

Extracted from Wright (1968)

James' ideas of minimal immobilisation have been widely adopted in Britain, but many surgeons in other countries do not agree. Strickland *et al.* (1982) reviewed 415 phalangeal fractures and presented figures which they interpreted as showing little difference in the final range of active movement between fingers mobilised immediately and those immobilised for up to three weeks, though there was much more stiffness if the fingers were splinted for four or more weeks. However, they emphasised that the phalangeal fractures in their study represented those seen in a practice devoted entirely to surgery of the hand and were therefore more severe than those from a normal casualty department. In fact, when the amount of displacement was taken into account, the small number of minimally displaced fractures which were mobilised at once, clearly did better than those which were immobilised, whereas in markedly displaced fractures there was little difference provided splintage was not maintained for more than three weeks. However, Dobyns, Linscheid and Cooney (1983), reviewing developments in the management of hand fractures over the last 20 years, concluded that "Now, as then, the earlier the restoration of at least a partial arc of motion, the better the final result."

It would seem, therefore, that here again the type of fracture determines the treatment: many of those with little or no displacement need not be immobilised at all. In more severe injuries it is unlikely that the patient will be able to achieve much active movement in the early stages, so he may as well be spared the pain and have the fracture immobilised for a week or two, during which time the hand can be elevated to diminish the swelling. Any fracture which has needed reduction will also need immobilisation to maintain that reduction.

Internal fixation. What is the role of internal fixation? In theory, it should convert unstable fractures into stable ones so that, with these also, movement may be started without delay. James (1962) found that only 2 out of 25 phalangeal fractures treated by internal fixation regained full function, but remained hopeful that with improved techniques better results would be obtained. I was similarly disappointed with the results of internal fixation (Barton 1979a), though of course the cases selected for this method of treatment are those with a worse prognosis.

One attractive way to gain stability without incurring the disadvantages of exposing the fracture is by percutaneous fixation with Kirschner wires. This has been recommended by Green and Anderson (1973) and by Joshi (1976). However, I have found that, in the type of cases needing internal fixation, it is often difficult to obtain complete and accurate reduction without seeing the fracture, and that the presence of the wire passing through the soft tissues limits or prevents early mobilisation.

Among the most enthusiastic proponents of internal fixation have been Heim and Pfeiffer, authors of the *Small fragment set manual*. In the first edition (1974) they claimed that "rigid internal fixation enables us to achieve much better results than procedures known hitherto, provided that the described techniques are carefully adhered to." Statistics are given showing that there is a good prognosis with metacarpal fractures which are fixed with screws and plates, and internal fixation is recommended for Bennett's fracture-subluxations, fractures of the base of the first metacarpal distal to the joint, fractures of the neck of the fifth metacarpal, and various others. They gave no comparative figures for conservative treatment, though many British surgeons will consider that there is a good prognosis for these metacarpal fractures not fixed with screws and plates.

In the phalanges, they found that the results were significantly poorer, and stressed that the final results of postoperative treatment can be unsatisfactory, and that the operation itself can be very difficult. No surgeon with much experience of operations on phalangeal fractures will disagree with either of these statements: if experts find the operations difficult, they are not likely to be done well by an inexperienced and tired registrar in the middle of the night. The fact is that internal fixation of small bones is more difficult than of large bones, because the margin for error is smaller, and it is all too easy to submit the finger to the hazards and disadvantages of an operation without achieving the benefits of rigid fixation, so that in the end the finger is stiffer than if it had never been treated. These operations should therefore only be undertaken after careful consideration, in optimal conditions, and by the most experienced surgeon available. If screws or plates are being used, one should follow the principles and techniques described in the *Small fragment set manual*. This book is exactly what its title says: an instruction manual for the use of the equipment, not a

textbook on methods of fracture treatment. It may be compared to the instruction manual you receive with a new car, which tells you how to use the car but not when; it is assumed that you will be driving rather than walking or taking a bus.

It is interesting that in the second edition (1982) of the manual, further experience has led to a perceptible retreat from the authors' earlier position. For example, plating of fractures of the neck of the fifth metacarpal has been abandoned, and conservative treatment is recommended "if there is not too much angulation": if operation is performed, they advocate a small tension-band wire loop. In fact, they say (though not in the book) that they treat 90% of hand fractures conservatively.

It is therefore necessary to define the indications for internal fixation precisely, and ensure that it is carried out by a surgeon trained and experienced in this type of work. Only about 5% of hand fractures need internal fixation. The indications given by Robins in 1961 remain valid:

Fig. 12

Lister's method of intra-osseous wiring. This may be used for arthrodesis as well as for fractures.

Fractures of the shafts of the phalanges if closed reduction fails to achieve perfect position. The dorsal soft-tissue hinge is usually intact, and most fractures can be reduced by manipulation, after which they should be splinted for three weeks in the position of immobilisation described above. However, in some cases, the fracture cannot be completely reduced by closed means and open reduction is required; this should probably be maintained by internal fixation to allow early movement and to prevent the tendons from getting stuck down.

If the fracture is oblique, then satisfactory fixation can be achieved by two parallel Kirschner wires or, if the surgeon is experienced in their use, by AO mini-screws. With this type of fracture, one must see both sides of the phalanx to ensure perfect reduction, so midlateral incisions on each side are needed.

However, in transverse fractures, these techniques are not applicable. Fyfe and Mason (1979) have shown in cadaveric studies that the most rigid means of fixation is by crossed oblique Kirschner wires, or by the method described by Lister (1978) using one oblique Kirschner wire and a compressing loop of malleable wire (Fig. 12). The latter technique is difficult and usually needs exposure of both sides of the phalanx. For general purposes crossed oblique wires remain the most satisfactory, provided that care is taken to avoid distraction of the fracture surfaces. The operative technique has been very well described by Edwards, O'Brien and Heckman (1982).

Fractures involving a joint, with either a large fragment carrying a significant proportion of the articular surface, or with subluxation. Most articular fractures are only tiny flakes of bone pulled off by the ligament or capsule attached to them; internal fixation is impossible and, of course, unnecessary. Opinions differ as to whether the finger should be immobilised or not; most cases will do well either way.

There are, however, two types of articular fracture where internal fixation may be required.

1, Oblique fractures of the condyle of the head of a phalanx. These fractures are rare, but James (1962) regarded them as the principal indication for primary internal fixation because the results of conservative treatment are always poor. This applies particularly to displaced fractures of the head of the proximal phalanx. In the middle phalanx the fragment is so small that fixation is very difficult, and it may be wiser to accept the resulting stiffness and deformity of the distal interphalangeal joint which are much less troublesome than at the proximal interphalangeal joint.

Fig. 13

Fig. 14

Oblique fracture of the condyle of the head of the proximal phalanx before (Fig. 13) and after (Fig. 14) open reduction and fixation with a mini-screw to restore a smooth articular surface.

The largest series of this type of fracture is that reported by McCue *et al.* (1970) who treated 35 patients by open reduction and fixation with two Kirschner wires. The joint was then immobilised in 25° of flexion for three weeks. Excellent results were obtained: 34 patients regained 80° of flexion, and the other patient 70°.

I prefer not to open the proximal interphalangeal joint, but to expose the fracture from the side. If the

visible part of the fracture is perfectly reduced then the intra-articular part also should be perfectly reduced (Barton 1984). The best fixation can be achieved with a very small screw, using the lag technique to compress the fracture surfaces together (Figs 13 and 14). It is then possible to start moving the joint the next day.

2, Fracture-subluxations. These uncommon injuries have, for some reason, been the subject of more publications than any other type of fracture in the hand.

Bennett's fracture-subluxation has already been mentioned. If good reduction cannot be obtained and maintained conservatively, then the subluxation should be reduced by closed manipulation and held by percutaneous wire-fixation across the joint (leaving the fracture to look after itself), as described by Wagner (1950); the wire is left in for six weeks (Figs 15 and 16). Exposure and fixation of the fracture itself is neither necessary nor desirable.

Fig. 15

Fig. 16

Bennett's fracture-subluxation before (Fig. 15) and after (Fig. 16) reduction; the carpometacarpal joint has been transfixed by a percutaneous Kirschner-wire. Observe that when the subluxation is reduced, the fracture also is reduced.

Fig. 17

Fig. 18

Figure 17—Fracture-subluxation of the proximal interphalangeal joint. Most of the joint surface on the distal fragment is displaced dorsally. Figure 18—The same finger after reducing the subluxation and transfixing the joint with a percutaneous Kirschner-wire. This is protected by an aluminium splint.

Fracture-subluxations of the proximal interphalangeal joint can be treated in a similar way (Figs 17 and 18), introducing the Kirschner wire through the bare area of bone on the back of the base of the middle phalanx (distal to the insertion of the central slip, but proximal to the conjunction of the two lateral slips). The wire is removed after three or four weeks, and it is surprising how quickly movements are regained.

Multiple fractures in the hand. Between 5% and 10% of patients have more than one fracture. The more fractures there are, the stronger becomes the case for internal fixation, as these injuries are, by definition, severe. They produce a lot of swelling and are often associated with soft-tissue damage; there is therefore great risk of stiffness. Fractures of several metacarpals are particularly difficult to manage conservatively because, whereas fractured phalanges have angulation which is concave dorsally and therefore improved by attempts to flex the fingers, metacarpal fractures are concave anteriorly and early mobilisation tends to produce flexion at the fracture site instead of at the metacarpophalangeal joint. In severe injuries of this nature, rigid fixation of the metacarpals with plates and screws is the only method which permits early movement of the joints (Figs 19 and 20).

To these indications given by Robins may now be added another.

Fractures in digits which have been amputated or nearly amputated and are reattached or revascularised using microvascular techniques. These operations are time-consuming and difficult, and are indicated in only a minority of cases. Nevertheless, no late reconstructive procedure will create anything as good as a successfully reattached thumb, and amputation or devascularisation of several fingers also justify reattachment and revascularisation. Although time is at a premium, it is necessary to fix the bone first, to stabilise the digit before starting the microvascular anastomoses (Hoffman and Buck-Grumko 1982).

REHABILITATION

This is the most important aspect of treatment, because it is necessary in every patient, and because it is no use splinting or operating on a finger if it ends up stiff. A stiff finger gets in the way and is worse than no finger at all.

The value of early mobilisation of stable fractures is that, by cutting out the steps of reduction and retention, rehabilitation can be started straightaway (Wynn Parry 1981). It is our responsibility as surgeons to initiate this process. Filling in a physiotherapy card is no substitute; first, because hand injuries would swamp the physiotherapy department, and secondly because even physiotherapists are understandably reluctant to encourage movements which cause pain in a fresh fracture. It is therefore up to the surgeon to explain to the patient that, although it may hurt, it will do no harm to move the finger; indeed it would be more harmful to allow it to

stiffen. Next, the surgeon should demonstrate to the patient with his own hand what to do, and then get the patient to do it in front of him until satisfied that he has understood. Gentle passive assistance with the other hand may also be helpful, but not forcible manipulations or what Macaulay calls "the imposition of a mightier

and Jones (1983) compared patients with various superficial soft-tissue injuries of the hand treated by pulsed electromagnetic energy (Diapulse) for half-an-hour twice daily with similar patients not so treated; they found less swelling, less pain, and better function in the treated group. Unfortunately, it is not clear whether the control

Fig. 19

Fig. 20

Figure 19—Multiple fractures in the hand. The patient was driving a car which rolled over. Figure 20—The same hand after internal fixation. A full range of movement was regained.

hand". The patient should be told *not* to squeeze a rubber ball or a piece of putty, as some well-meaning friend may suggest, because that may displace or redisplace a phalangeal fracture, and anyway prevents full flexion, which is what is needed. Once a good range of movement has been regained, power will return with normal use.

If the surgeon spends a few minutes on these simple instructions for the routine cases, the physiotherapist can spend her time and use her skill where it is really needed, namely in the more serious cases after any necessary period of immobilisation, and in those which have been treated by internal fixation.

The role of special forms of physiotherapy, other than mobilising exercises, is not yet clear. Barclay, Collier

group received conventional physiotherapy, so one cannot be sure that the benefit was due to the Diapulse. Fractures were excluded, though the current interest in treating fractures by electrical stimulation would seem to have justified their inclusion in the trial.

However, it is likely that, for the physiotherapist, as for the surgeon, simple methods will generally be the most effective. The aim of treatment is, of course, the resumption of normal activities. Nevertheless in most cases it is not necessary for the patient to wait until recovery is complete before going back to work: that is the final stage of treatment and the most effective therapy. The best way to make the hand work is to make the hand work.

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