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ELBOW-WRIST-THUMB IMMOBILISATION IN THE TREATMENT OF FRACTURES OF THE CARPAL SCAPHOID

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Fractures of the carpal scaphoid are the most common of the carpal bone injuries, amounting to 65 per cent of the fractures and dislocations of all the bones of the carpus. Due to the high frequency of delayed union, pseudarthrosis and necrosis and the significant disability caused to the wrist joint, these fractures have been studied extensively and many methods of conservative and/or surgical treatment have been proposed.

This work has been undertaken in order to determine in anatomical specimens optimal position of the elbow-wrist-thumb immobilisation for the conservative treatment of fresh fractures of the carpal scaphoid. As optimal position, the one considered was that securing reduction under compression and full immobilisation of the fracture. The experience gained by this study was later used for treatment of a series of patients. The results obtained by the treatment are reported briefly.

MATERIAL AND METHODS

Anatomical specimens of the upper extremities, including the shoulder joint from six cadavers, were used for the present study. Full range of motion existed in the joints of all specimens. All muscles of the dorsal surface of the forearm from its middle part down to the middle of the metacarpal bones, as well as those of the radial aspect of the forearm, were removed. Remaining soft tissues and joint capsule were also removed from the radial half of the wrist. The interosseous ligament of the forearm as well as the collateral ligaments of the wrist were preserved.

A transverse fracture at about the middle part of the scaphoid was brought about with an osteotome. This type of fracture was chosen as it is the most common in everyday practice (Stewart 1954, Böhler 1956, Russe 1960, London 1961, Watson-Jones 1962, Persson 1970).

The material was divided into two groups. Three hands were used to study the

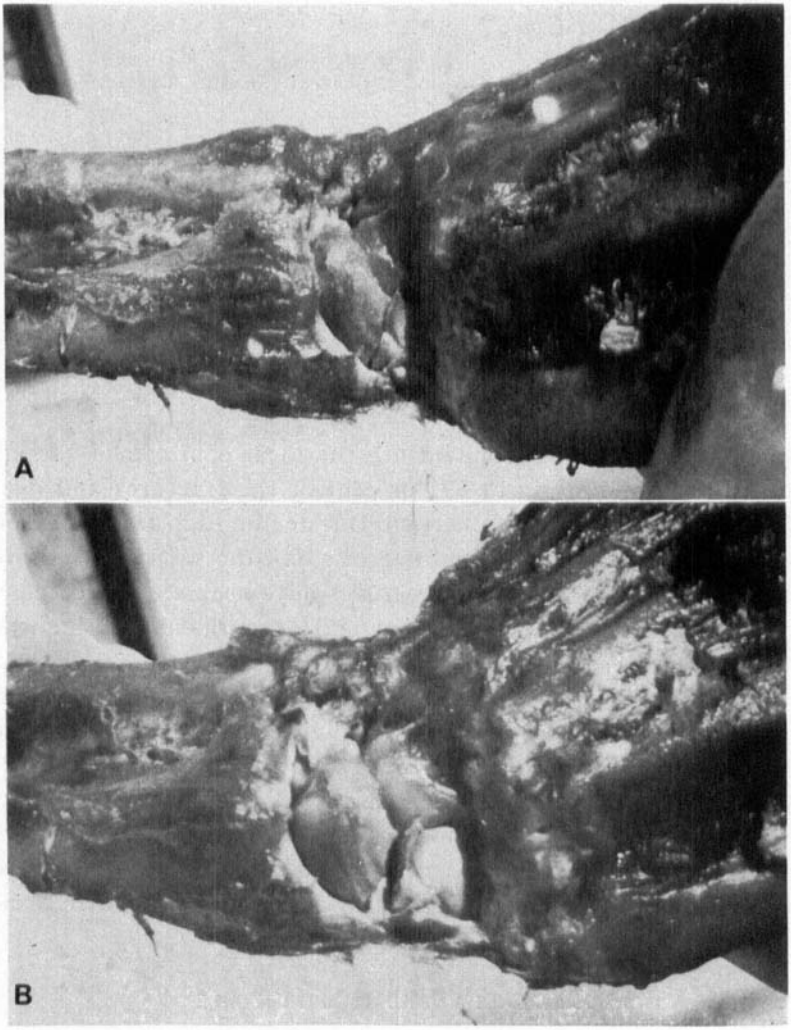

Figure 1. Left hand specimen. The fracture brought about in the middle of the carpal scaphoid is seen from the superficial dorsal level.
(a) The fracture is reduced by dorsal flexion and radial deviation of the hand.
(b) Dorsal flexion and ulnar deviation result in diastasis of the fragments.

fracture on either of two levels: The superficial dorsal, and the deep palmar level. In the first group the wrist was integral and the fracture was studied from the dorsal aspect (Figure 1). In the second group the dorsal half of the thickness of the radial part of the carpus together with the adjacent part of the radius were excised with a saw. In this way the deep palmar half of the fractured carpal scaphoid was available for study (Figure 2).

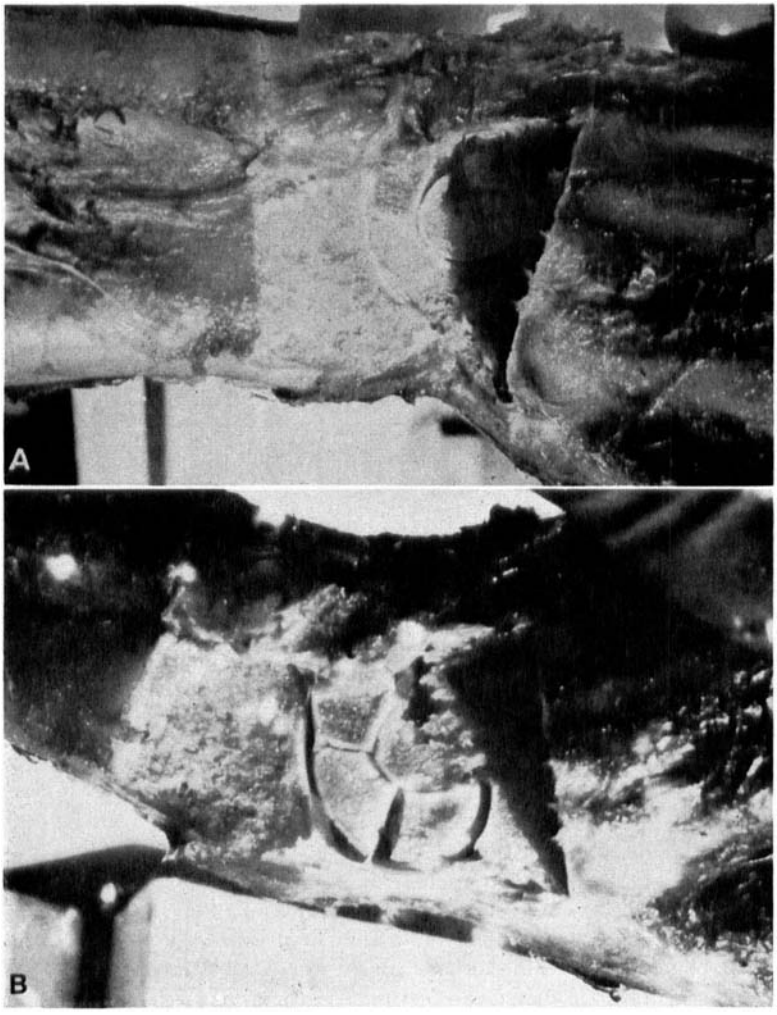

Figure 2. The same conditions as in Figure 1 are seen at the deep palmar level of the carpus.
(a) Dorsal flexion and radial deviation of the hand reduce the fracture.
(b) Dorsal flexion and ulnar deviation result in diastasis between the fragments.

The effect of the position of immobilisation on the fracture was assessed by macroscopical observations and roentgenological studies.

Position of Forearm—Wrist—Thumb:

It was proved in both groups that among different positions of immobilisation optimal reduction and compression of the fragments were achieved with the forearm in middle position, i.e. the elbow in 90° of flexion, and the wrist in 25–30°

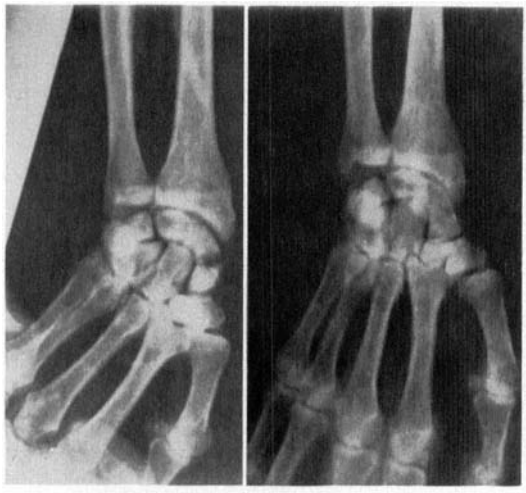

Figure 3. Radiographic verification of the observations in Figures 1 and 2.

dorsal flexion and about 20° radial deviation (Figure 1 a and 2 a). If the radial deviation was changed into ulnar deviation distraction of the fragments occurred (Figure 1 b and 2 b). This was confirmed by radiographic observations as well (Figure 3). Movements of the thumb and first metacarpal bone resulted in slight movement of the distal fragment. Pronation and supination of the forearm resulted in obvious movement of the fracture fragments of the bone in the above-mentioned position of the wrist.

Extent of the Plaster Cast:

A cast was applied in the forearm beginning just distal to the elbow and extending down to the heads of the four ulnar metacarpal bones. The wrist was immobilised in about 30° dorsal flexion and 20° radial deviation. The thumb, opposing the third finger, was included up to the middle of the distal phalanx with the first metacarpal bone aligned with the axis of the radius. Special attention was paid to the application of the cast on the palm. The forearm was put in mid-position between pronation and supination when the plaster cast was set. Through a small opening made on the dorsal aspect of the cast, observation of the fracture was possible. With the elbow flexed at 90°, pronation and supination movements were carried out covering a total arch of about 125°, i.e. pronation of approximately 55° and supination of 70° from the mid-position. This resulted in movement of the fractured fragments of the scaphoid (Figure 4).

Each of the six specimens was further pronated and supinated 10 times in a total arch of 125°–130°. In 47 out of these 60 tests there was clearly visible movement between the fractured fragments. However, exact reposition of the fragments was achieved when the forearm reached the mid-position, suggesting that this position of the forearm is the one of choice for immobilisation. In the remaining 13 tests there was either no visible movement within the fracture or no reposition of the dislocated fracture.

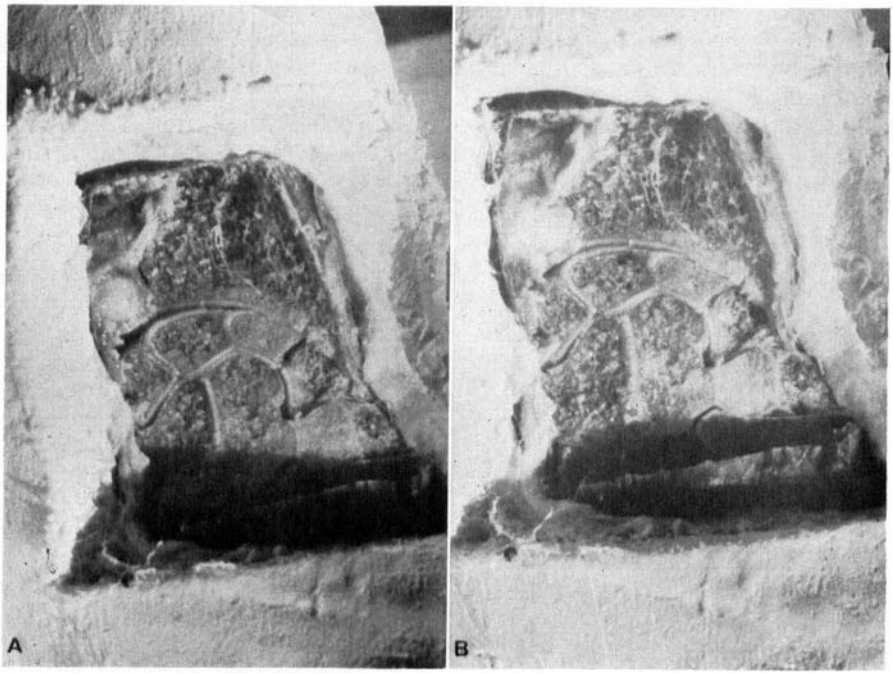

Figure 4. Right hand specimen with fracture of the scaphoid. Immobilisation of the hand by a short plaster cast.
There is a clear difference in the position of the fracture fragments between maximal pronation (a) and maximal supination (b).

Flexion and extension movements of the elbow (5°–130°) with the forearm in mid-position did not influence the reduction of the fracture.

From these observations it was concluded that the application of a cast including the elbow at an angle of about 90° and the forearm in mid-position between pronation and supination is a prerequisite for good retention of the reduced fracture.

Clinical Observations

The experience gained from the observations referred to above was applied in the treatment of 25 fresh fractures of the carpal scaphoid during the years 1964–1970. Males 21, females 4. Average age: 31 years, range 47 and 21 years. 19 males and 2 females were laborers.

Treatment was initiated in 19 cases 4–15 days after the accident. In 4 cases 15–21 days and in each of one case 7 and 9 weeks respectively.

Immobilisation was achieved by the use of a plaster cast extended from the middle of the humerus to the heads of the 4 ulnar metacarpal bones and the base of the nail of the thumb. A thin layer of cotton was applied before casting the extremity. Special care was taken in molding the cast in the palm. The elbow was flexed

at an angle of 90° and the forearm was placed in the mid-position: the carpus in a dorsal extension of about 25° and a radial deviation of about 20°, the thumb, opposite the third finger, with its metacarpal bone aligned with the axis of the radius and its joints in slight flexion.

Change of the cast and new radiographic examination were performed every 6th week, the new cast being placed in identical positions of the joints. Immobilisation of the elbow was usually restricted only to 6 weeks. The total period of immobilisation of the wrist varied from 8 to 18 weeks. Average period of immobilisation: 88 days or 12½ weeks.

Table 1. The clinical material.

Localisation of the fracture	No. of cases	Percentage	Healed	Pseud-arthrosis	Aseptic necrosis
Middle 3rd	16	64	13*	3	–
Distal 3rd	5	20	5	–	–
Proximal 3rd	4	16	2	–	2§
Total	25	100	20	3	2

* One case was not submitted to treatment until 7 weeks after the injury.
§ One case was not submitted to treatment until 7 weeks after the injury.

RESULTS

On a total of 25 fractures of the carpal scaphoid treated according to the principles described above there were 5 or 20 per cent failures, i.e. 3 pseudarthroses and 2 aseptic necroses. The latter occurred in fractures of the proximal 3rd of the scaphoid, one of which was not submitted to treatment until 9 weeks after the injury (Table 1).

DISCUSSION

Besides the local condition of vascularisation, healing of fresh fractures of the carpal scaphoid is largely dependent on a good reduction, sufficient compression and adequate immobilisation of the fracture fragments.

As to the forearm-wrist-thumb optimal position, for reduction, compression and immobilisation of the fracture, there is no general agreement. Fixation of the wrist in dorsal extension as required for "functional position" of the hand or "formation of fist", is commonly advocated (Böhler 1956, Boitzy 1958, Watson-Jones 1962, Mazet & Hohl 1963, Broomé et al. 1964, Mazet 1967, Apley 1968, Broomé et al. 1968, Goldman et al. 1969. DePalma 1970, Persson 1970, Salter 1970).

The position of fixation is not defined by several authors (Wallensten et al. 1959, Adams 1969); fixation of the carpus in flexion (Speed 1925) or hyperextension (Hosford 1931) have also been suggested.

Fixation of the wrist in dorsal flexion is specially recommended by Stewart (1954), Squire (1959), Verdan (1960) and Verdan & Narakas (1968).

Observations made on cadavers have shown that radial deviation of the wrist promotes the reduction of the fracture and secures good compression of its fragments (Haw 1963). It has been pointed out that fixation of the wrist in radial deviation results in good reduction and compression of the fracture (Friedenberg 1949, Müller et al. 1963).

Fixation of the wrist in ulnar deviation is recommended by Bunnell (1956) and Squire (1959) and seems to be suggested by those advocating fixation in "functional position" or "formation of fist" since this position puts the wrist in slight ulnar deviation.

Fixation of the wrist in dorsal flexion and radial deviation has been suggested by several authors (Berlin 1929, Sotto-Hall & Haldeman 1934, Sotto-Hall 1945, Friedenberg 1949, Haw 1963).

The conclusions drawn from the present study as to the optimal position of the wrist between volar and dorsal flexion and radial and ulnar deviation are in agreement and support the view that fixation of the wrist in dorsal flexion and radial deviation secure optimal conditions for healing of the fracture of the carpal scaphoid.

The position of the thumb in the plaster cast is also a subject of dispute. The thumb is not included at all in the cast (Friedenberg 1949, Böhler 1956, Russe 1960) or is immobilised in the plaster cast (Stewart 1954, Bunnell 1956, Key & Conwell 1956, Wallensten et al. 1959, Broomé et al. 1968, Adams 1969, DePalma 1970, Salter 1970). The results of the present study suggest that movements of the thumb and the 1st metacarpal bone resulted in movements of the distal fragment of the fractured scaphoid, transmitted through the articulation of the thumb with the greater and lesser multangular bones, and are in agreement with earlier observations (Stewart 1954, Key & Conwell 1956, Watson-Jones 1962). Fixation of the thumb somewhat flexed in opposition to the 3rd finger, with its metacarpal bone aligned to the axis of the forearm, and not in abduction, has been proved by this work to be optimal for the reduction, compression and immobilisation of the fractured scaphoid.

There is also disagreement as to the extension of the plaster cast and especially as to the necessity for immobilisation of the elbow joint to

achieve optimal conditions of healing. Full immobilisation of the wrist and not the position of immobilisation has been emphasized to be of supreme importance (Bunnell 1956, Böhler 1956, Russe 1960, Watson-Jones 1962, Müller et al. 1963, DePalma 1970).

The prevailing view today is for the "short cast", extending from just distal to the elbow to immediately proximal to the heads of the metacarpal bones of the fingers, including the 1st metacarpal with or without the thumb with plaster, fitted especially well around the palm. Inclusion of the fingers in the cast is also supported (Snodgrass 1933, Nenninger 1955).

However, the "short cast", no matter how good the application might be, allows movements of pronation and supination of the forearm in an arch varying from 100° to 125°. Movements of pronation and supination of the forearm result in movements of the fractured parts of the carpal scaphoid, a fact proved on anatomical specimens as well as by radiographic examinations by earlier authors (Verdan 1954, 1960, Boitzy 1958, Squire 1959, Frykman 1960, Haw 1963, Verdan & Narakas 1968) and by the present work. These observations strongly suggest the necessity for the extension of the plaster cast to include the elbow; this is supported by other authors (Broomé et al. 1964, 1968, Persson 1970). Immobilisation of the extremity with the forearm in full supination has also been suggested (Squire 1959, Haw 1963).

The superiority of the results of treatment according to the principles discussed above, with regard to the period of immobilisation and the frequency of union as compared with the results of parallel series treated with a "short cast", has been pointed out by several earlier authors (Boitzy 1958, Frykman 1960, Broomé et al. 1964, 1968, Persson 1970). No significant difference in the results of similar observation has been reported (Goldman et al. 1969).

With regard to the duration of the immobilisation of the wrist until the fracture is healed, there is a practical rule accepted by most authors, i.e. that the length of the period of immobilisation needed for healing of the fracture is proportional to the distance of the line of the fracture from the distal pole and/or to the time which has elapsed between the occurrence of the fracture and the initation of the treatment.

Average duration of immobilisation of 10–14 weeks until healing is usually reported; much longer durations are also stated for good results, as e.g. 60 weeks (Robertson & Wilkins 1944), 50 weeks (Wallensten et al. 1959) and as much as 26 months (London 1961).

The rate of failures in the conservative treatment of fractures of the scaphoid varies considerably in different reports. Thus, frequencies as low as 5 to 17 per cent (Stewart 1954, Böhler 1956, Russe 1960, London 1961, Watson-Jones 1962, Broomé et al. 1968) and as high as 40 to 42 per cent (Dickison & Shannon 1944, Adams 1969, DePalma 1970) have been reported.

Failure of healing as in delayed union or pseudarthrosis may be attributed mainly to the technique and the time of immobilisation as well as to the time elapsed between the accident and the initation of the treatment.

According to Böhler (1960) a fracture of the scaphoid is considered as "fresh" up to the 6th week after the injury, a time limit which is, however, arbitrary. However, for aseptic necrosis in fractures of the proximal 3rd of the scaphoid vascularisation rather than technical factors may be considered responsible for the failure. Indeed, if there is a disruption of the circulation of the proximal 3rd, necrosis occurs regardless of the effectiveness and the prolongation of the immobilisation even in fresh fractures. These fractures as well as crush fractures of the scaphoid should actually be disregarded when judging the incidence of failures. The same is valid for simple cracks which almost always heal.

The present series included 25 complete fractures. None of them was a crush fracture and there was no major dislocation of the fragments in any case. Healing occurred in altogether 20 cases. If, for the reasons mentioned above, the 4 fractures of the proximal 3rd of the scaphoid, 2 of which resulted in aseptic necrosis, are excluded, then the failure rate in this series will drop from 20 to 14 per cent. This fact is considered to support the principles followed in the treatment of fractures of the scaphoid in this series.

SUMMARY

Studies have been carried out to determine the optimal position of immobilisation of the wrist and of the extension of the plaster cast for the treatment of fractures of the carpal scaphoid.

In 6 anatomical specimens of the upper extremity in cadavers a fracture in the middle of the scaphoid was brought about. Studies including macroscopical observations and radiographic examinations were carried out on two different (superficial and deep) levels of the carpus.

Full reduction, sufficient compression and adequate immobilisation of the fractured bone were secured only when the applied plaster cast included the elbow and the thumb, with the forearm in mid-position between pronation and supination, the wrist in 25° dorsal flexion and about 20° radial deviation and the 1st metacarpal aligned to the longitudinal axis of the radius.

Using the experience gained from these studies, 25 cases of fracture of the carpal scaphoid were treated according to the described principles. Four were fractures of the proximal 3rd of the bone, one of which was due to a 9-week-old injury. This and another case resulted in necrosis of the proximal fragment. Among the remaining 21 cases, consolidation of the fracture occurred in 18 cases, a healing rate of 85 per cent. In these cases the mean time of immobilisation was 12½ weeks.

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