9 Carpometacarpal (CMC) Dislocations or Fractures-Dislocations Excluding the Thumb

9.1 Introduction

Malgaigne in 1855 stated that up to that time only three cases of dislocation of Carpometacarpal (CMC) joints had been reported. The first of these cases was an isolated dislocation of the base of the third MC, reported by Blandin in 1844. The second case, also an isolated dislocation of the base of the third MC, was reported by Roux in 1848; and the third case was an isolated dislocation of the base of the second MC reported by Bourguet in 1853. Vigouroux, in 1856, was the first to report a multiple CMC dislocation, involving the bases of the second, third, fourth and fifth MC; Rivington, in 1873, was the first to report a case of multiple dislocations of the bases of all five metacarpals (cited by Waugh and Yancey [1]).

In contradistinction to the thumb CMC joint, injuries of the four ulnar CMC joints are referred to as "finger carpometacarpal" [2] or as "medial four CMC" [3] injuries.

Although CMC injuries of the thumb are not uncommon, those of the base of one or more of the four medial metacarpals are rather rare. The clinical problems arising from injury of the 2nd to 5th CMC joints differ sufficiently from those of the thumb, to warrant separate consideration [4].

Dislocations of the CMC joints disrupt the normal transverse and longitudinal arches of the palm, impair grip strength, and can also affect the balance between intrinsic and extrinsic muscles when there is proximal displacement of the metacarpal. This displacement causes laxity of the extrinsic muscle tendons. Sterling Bunnell in 1944 [5] was the first to emphasize the importance of early anatomical reduction of all CMC dislocations, when he supported that "reduction is necessary to restore muscular balance and proper mechanics of the hand".

Injuries of the CMC joints are rare and represent less than 1 % of all wrist and hand injuries [6, 7]. Dobyns et al. [8] reported only 3 such injuries in a series of 1,621 fractures and dislocations of the hand and wrist over 3 years at a military hospital (0.18 %).

In cases of CMC joint injuries, the coexistence of a distal carpal row fracture is quite frequent. Garcia-Elias [9] reported that out of 50 patients with traumatic fracture-dislocation of the CMC joints, 13 (26 %) also presented major fracture of the capitate, hamate or trapezoid, which resulted in subluxation or dislocation of the respective metacarpal base.

9.2 Anatomy

The CMC joints are anatomically stable and their stability is the result of: interlocking saddle joints, complex ligamentous support and dynamic protection by the long flexor and extensor tendons and intrinsic muscles [10].

The distal row of carpal bones forms a fixed transverse arch, while the ring and little fingers on the ulnar side of this arch and the thumb on the radial side, form two mobile longitudinal arches. Both longitudinal arches provide

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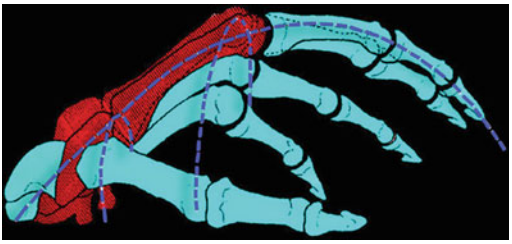


Fig. 9.1 The distal carpal row with the longitudinal arches of the index and middle fingers constitute the stable central unit of the hand. With permission from [132]

mobility about a fixed central unit comprising the index and middle fingers, whose metacarpals are firmly fixed to the distal carpal row [6] (Fig. 9.1). These bones establish the functional transverse and longitudinal arches of the hand.

Experimental studies have indicated less than 1° of motion in the flexion–extension plane at the second ray and 3° at the third ray. Conversely, the flexion–extension motion for the 4th ray is approximately 10°–15° and 15°−30° for the 5th ray [6, 11, 12].

A kinematic analysis of the 2nd through 5th CMC joints using three-dimesional computerized imaging, revealed that the overall flexion–extension motions of the 2nd, 3rd, 4th, and 5th CMC joints, were found to be 11°, 7°, 20° and 27°, respectively; in radial-ulnar deviation 2°, 4°, 7°, and 13°, respectively and in pronation-supination motion 5°, 5°, 27°, and 22°, respectively [13]. This study moreover revealed that the range of motion of the 5th CMC joint reduces by 40 % when the 4th CMC joint is immobilized.

The anatomy of the ligaments and the formation of the articular surfaces of the CMC joints have not been sufficiently described, not only because literature reports are few, but also because there is a considerable number of anatomic varieties [6, 12, 14, 15]. Harwin et al. [12] reported seven dorsal CMC ligaments and eight palmar CMC ligaments of the 2nd through 5th CMC joint. Gurland [6] reported six dorsal CMC ligaments and six palmar CMC ligaments. Nakamura et al. [15] described nine dorsal CMC ligaments and seven palmar CMC ligaments and specifically: dorsally he reported two for the 5th, two for the 4th, three for the 3rd, and two for the 2nd CMC joint (Fig. 9.2) and volarly: one for the 5th, one for the 4th, four for the 3rd, and one for the 2nd CMC joint. Nanno et al. [16] in a three-dimensional analysis of the ligamentous attachments of the 2nd through 5th CMC joints, identified 9 dorsal and 11 palmar CMC ligaments.

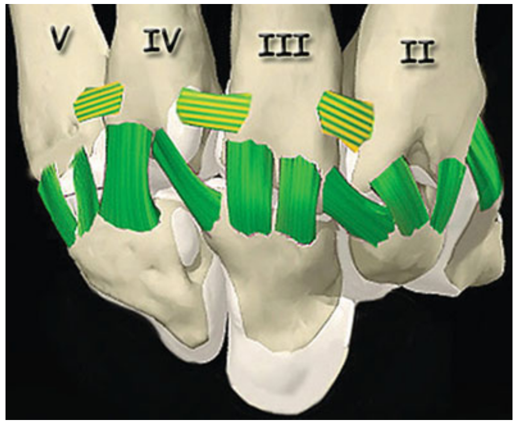


Fig. 9.2 The dorsal CMC and the three inter-metacarpal ligaments. With permission from [132]

Additional ligamentous restraint is provided by 3 dorsal and 3 palmar intermetacarpal ligaments that connect the bases of the metacarpals [15], while Nanno et al. [16] identified 4 dorsal and 4 palmar intermetacarpal ligaments of the 2nd through 5th CMC joints. In addition, one intraarticular ligament extending between the 3rd and 4th MC and capitate—hamate was also identified [15, 16], which secures stability even upon rupture of the dorsal and palmar ligaments. However, the role that these ligaments might play in the pathomechanics of axial disruptions and/or CMC dislocations and fracture-dislocations of the carpus has not been well described.

Of particular, importance is the pisometacarpal ligament extending between the pisiform and the ulnovolar base of the 5th metacarpal, through which the flexor carpi ulnaris exerts its effect (Fig. 9.3).

The strong periarticular ligamentous supports of the CMC joints render the anyway rare CMC fracture-dislocations, more frequent than pure dislocations. Although the dorsal ligaments are described as stronger and more distinct than their volar counterparts, dorsal dislocations are more frequent.

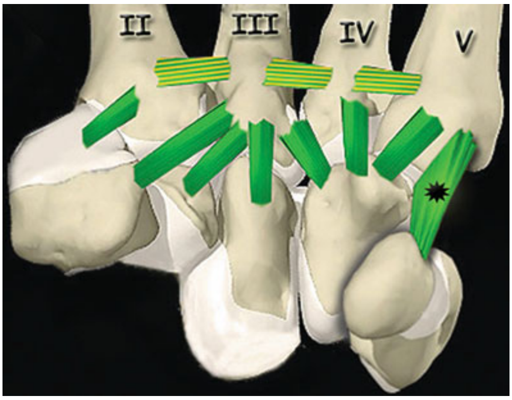


Fig. 9.3 The volar CMC and the three volar intermetacarpal ligaments. The pisometacarpal ligament is indicated with the *asterisk*. With permission from [132]

The extensor and flexor tendons of the wrist ensure dynamic stabilization by adhering to the base of the 2nd MC (flexor carpi radialis and extensor carpi radialis longus), the base of the 3rd MC (extensor carpi radialis brevis), and the base of the 5th MC (extensor carpi ulnaris and flexor carpi ulnaris via the pisometacarpal ligament) [6, 17] (Fig. 9.4a, b).

There is more variability and often multiple distinct joint surfaces forming the articulations between adjacent metacarpals and/or adjacent distal carpal bones. Nakamura et al. [15] recognized two types of articulation between the 2nd and 3rd MC, five types of articulation between the 3rd and 4th MCs, while the articulations between the 4th and 5th MCs, between the 2nd MC and the trapezium, and between the trapezoid and the trapezium were all single articulations. The authors also noticed that the area of the 2nd and 3rd CMC joints was found to have the highest incidence (18 %) of carpal coalition. Viegas et al. [18] reported that the joint surfaces between the 4th MC and the capitate and/or the hamate were variable and recognized 5 different types of articulation: A type I, with a single dorsal projection radially, a type II with a double projection radially, a type III with a narrow radioulnar dimension without any projection, a type IV with a narrow radioulnar dimension of the base and a separate small articular surface dorsoradially, and finally, a type V with a broad radioulnar dimension of the articular base of the 4th metacarpal.

The base of the 2nd MC has a cuneiform configuration and articulates with the corresponding surfaces of the trapezium-trapezoid. The 3rd metacarpal base has a dorsoradial styloid process that articulates with the base of

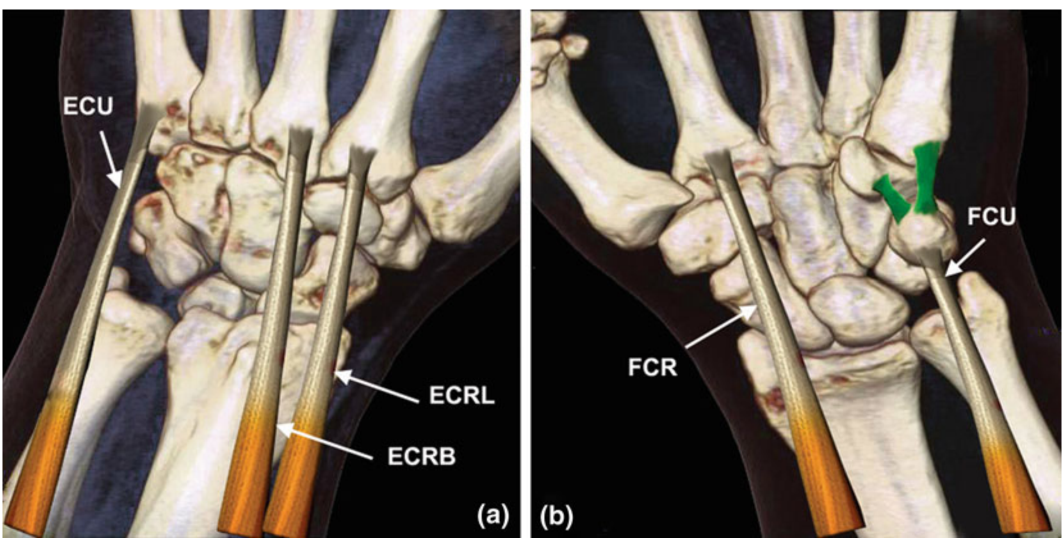


Fig. 9.4 The relation of the extensors (**a**) and flexor (**b**) tendons with the CMC joints. (*ECU* Extensor carpi ulnaris, *ECRB* Extensor carpi radialis brevis, *ECRL* Extensor carpi radialis longus, *FCR* Flexor carpi radialis, *FCU* Flexor carpi ulnaris)

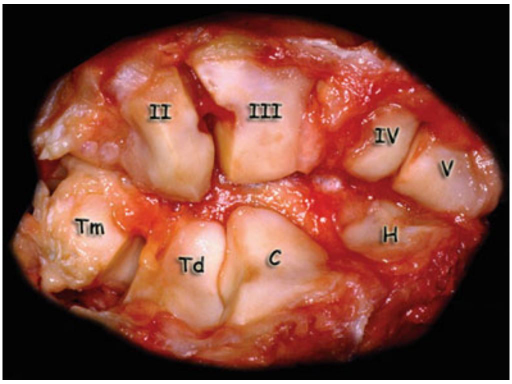


Fig. 9.5 The CMC joints opened dorsally and hinged volarly. The anatomic configuration is described in the text (*Tm* Trapezium, *Td* Trapezoid, *C* Capitate, *H* Hamate). With permission from [132]

the 2nd metacarpal, while ulnarly it has a double articular surface that articulates with the 4th MC and proximally with the capitate. The 4th and 5th metacarpals articulate with the saddle-shaped distal articular surface of the hamate. In general, CMC joints are saddle joints, where the metacarpal base is convex and the distal surface of the carpals is concave (Fig. 9.5). This relationship becomes less pronounced when progressing toward the ulnar column and is a major contributor to the decreased stability that the 4th and 5th metacarpals exhibit. This becomes a major factor in the relative frequency of CMC fracture-dislocations, with the 4th and 5th metacarpals being far more commonly involved [19].

9.3 Mechanism of Injury

Great and sudden force is required to disrupt the strong periarticular ligamentous supports of the CMC joints. The general consensus in the literature is that the dislocation of the CMC joints can occur either by a direct force on the bases of the metacarpals or by an indirect force transmitted via the metacarpal shafts [20].

These injuries are the result of traffic accidents, falls from heights or striking a hard object with a closed fist. However, a low-energy trauma has also been implicated [10, 21, 22].

In many cases, the axial force is transmitted along the metacarpal shaft, distally to proximally inducing a dislocation at the base of the metacarpal [9, 10, 17, 23–35]. This is the most likely of the mechanisms implicated in the dislocation of the 4th and/or 5th metacarpals, but also of the 2nd metacarpal [36], or of the 2nd to 4th metacarpals [37]. The actions of the ECU and the hypothenar muscles contribute to the deformity of this injury [38].

These injuries are also caused following the application of a force on the palmar surface of the wrist, while the wrist is dorsiflexed (dorsal dislocations), or the application of a force on the dorsal surface of the wrist, while the wrist is palmarflexed (palmar dislocations) [1, 2, 9, 12, 35, 39, 40].

Frequently, CMC injuries are produced after high-energy injuries (e.g., motorcycle accidents) in which, while gripping the handlebars at the time of collision, a significant amount of force is transmitted to the volar aspect of the metacarpal bases producing dorsal dislocations of the medial four CMC joints [2, 3, 20, 41]; in rare cases the handlebars act as a fulcrum causing the metacarpal base to dislocate volarly [42]. Kumar and Malhotra [43] described the need to apply a torsional force in a high-energy incident, to achieve a divergent variant of multiple CMC dislocations.

A rare type of injury, in which a palmarly dislocated 5th metacarpal is associated with a fracture of the hook of the hamate, has been described [44–48]. In this type of injury, a violent contraction of the FCU against a fixed wrist in dorsiflexion [45] or a direct mechanism of production [44, 46–48] has been implicated.

9.4 Clinical Evaluation

Clinical evaluation reveals either a blatant appearance with excessive swelling, pain, limited range of motion and signs of neurovascular dysfunction or in less severe injuries, mild swelling, and localized sensitivity above the affected joints. Sometimes splaying of the fingers is noted [49]. Waugh and Yansey [1] described the deformity of the more frequent

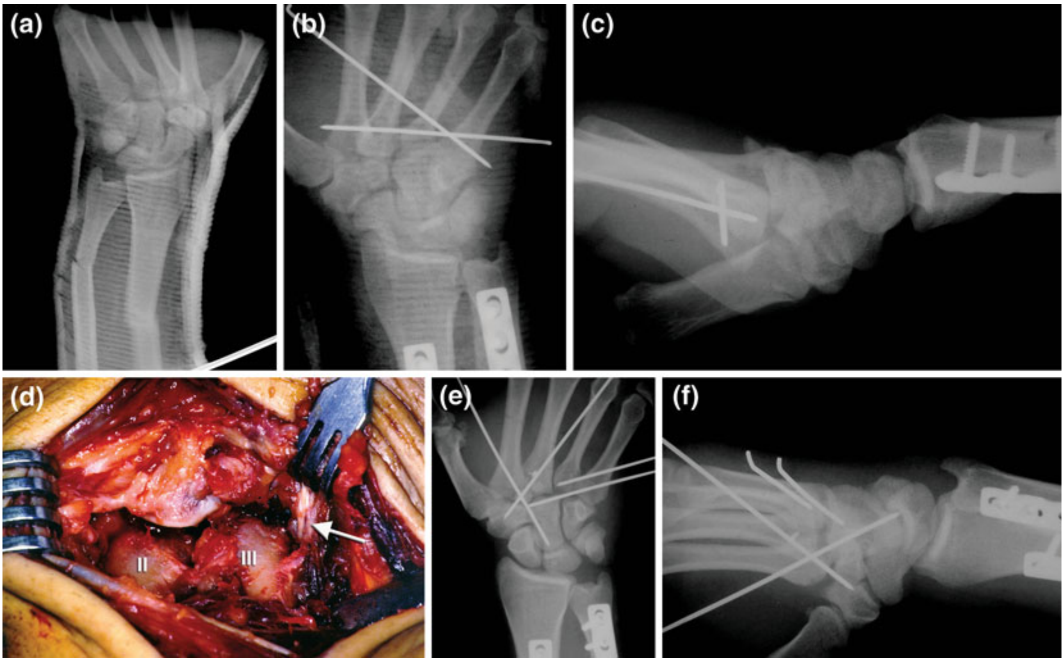


Fig. 9.6 Male, 18 years old, motorcycle accident. A forearm fracture was associated with volar dislocations of the 2nd to 5th metacarpals (**a**); after forearm reduction, the attempt for closed reduction and pinning of the CMC joints was unsuccessful (**b**, **c**); exploration through a dorsal approach revealed the avulsion of the ECRB from the base of the 3rd metacarpal (*arrow*) (**d**); a bone anchor was used for tendon reattachment and K-wires were inserted to stabilize the CMC joints (**e**, **f**). With permission from [132]

dorsal dislocations as "dinner- fork", while that of the volar dislocations as a "spade" type of deformity. Massive dorsal edema may obscure the characteristic clinical deformity and this, in combination with insufficient radiological control, are responsible for the high frequency of missed diagnosis [2, 6, 50–53]. Henderson and Arafa [27] reported that in 15 out of 21 cases with dorsal dislocations of the CMC joints, the diagnosis was missed at the emergency department, due to the swelling and use of routine radiographs. Garcia-Elias et al. [9] reported that 6 of their 13 patients had delayed or incorrect diagnosis. Shortening of the fingers, compared to the patient's healthy hand, will arise suspicion for injury of the CMC joints, once simple radiological examination rules out injury of the fingers or metacarpals (Indian salutation test [54]). With injuries to the 4th or 5th CMC joint, function of the motor division of the ulnar nerve may be affected because of that nerve's close proximity to the joint [6, 17, 52, 55–57]. This leads to weakness of the interossei and adductor pollicis, which manifests clinically as separation of the long and ring fingers when making a fist [10, 55]. Median nerve function may also be influenced in cases of palmar dislocations of the 2nd and 3rd CMC joints [9, 58], or of delayed reduction of central CMC joint dislocations or due to extensive swelling of the soft tissue. The close proximity of the deep palmar arterial arc with the palmar surface of the 3rd CMC joint must also be considered [17]. Another probable injury is the detachment of the flexor or extensor tendons of the wrist, which insert at the base of the affected metacarpal (Fig. 9.6a–f).

9.5 Radiological Evaluation

Diagnosis of CMC joint injuries is usually delayed due to insufficient initial radiological control. Gunther [3] stated that subtle findings in the overlapping articular surfaces and minor loss

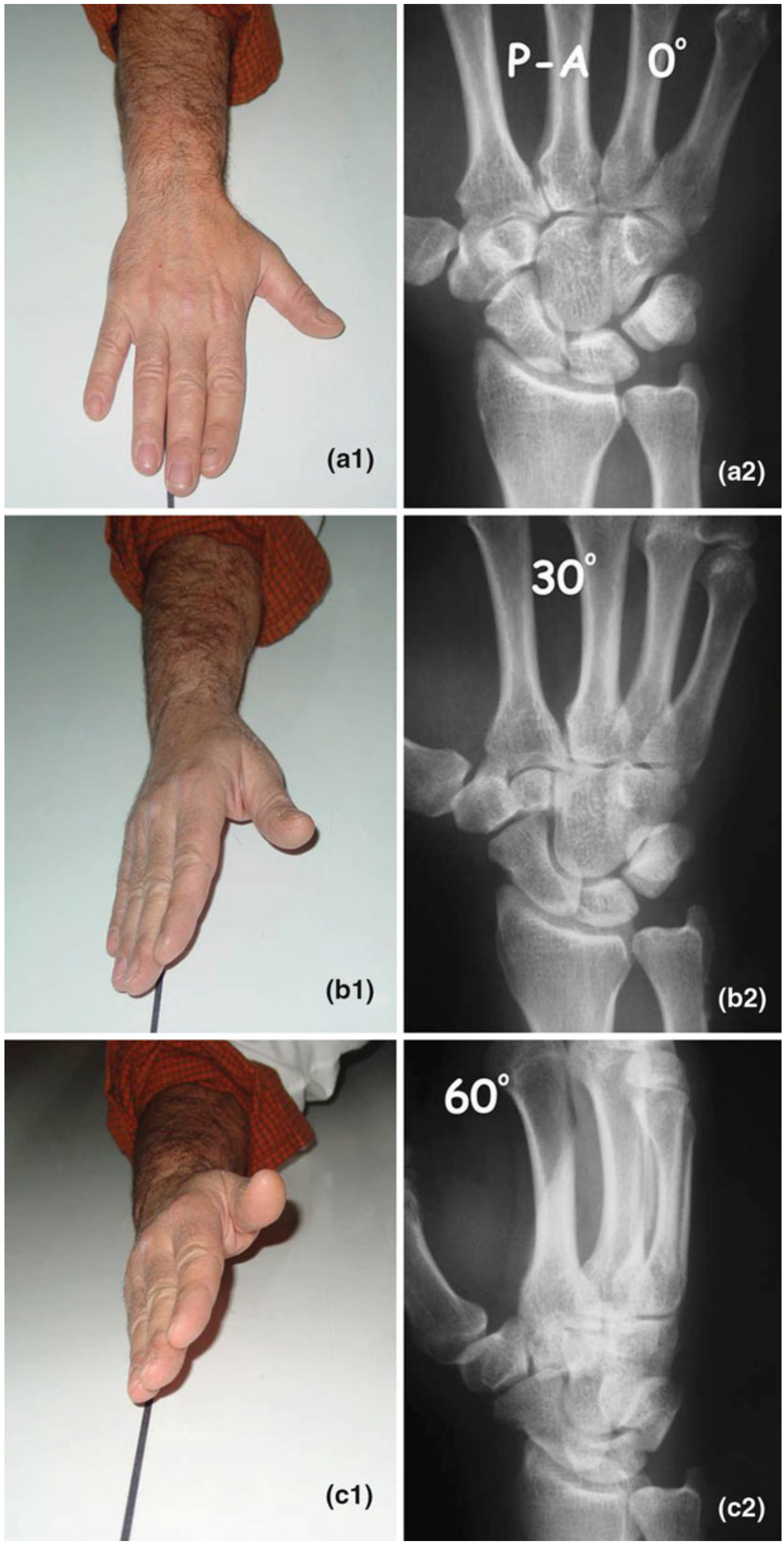
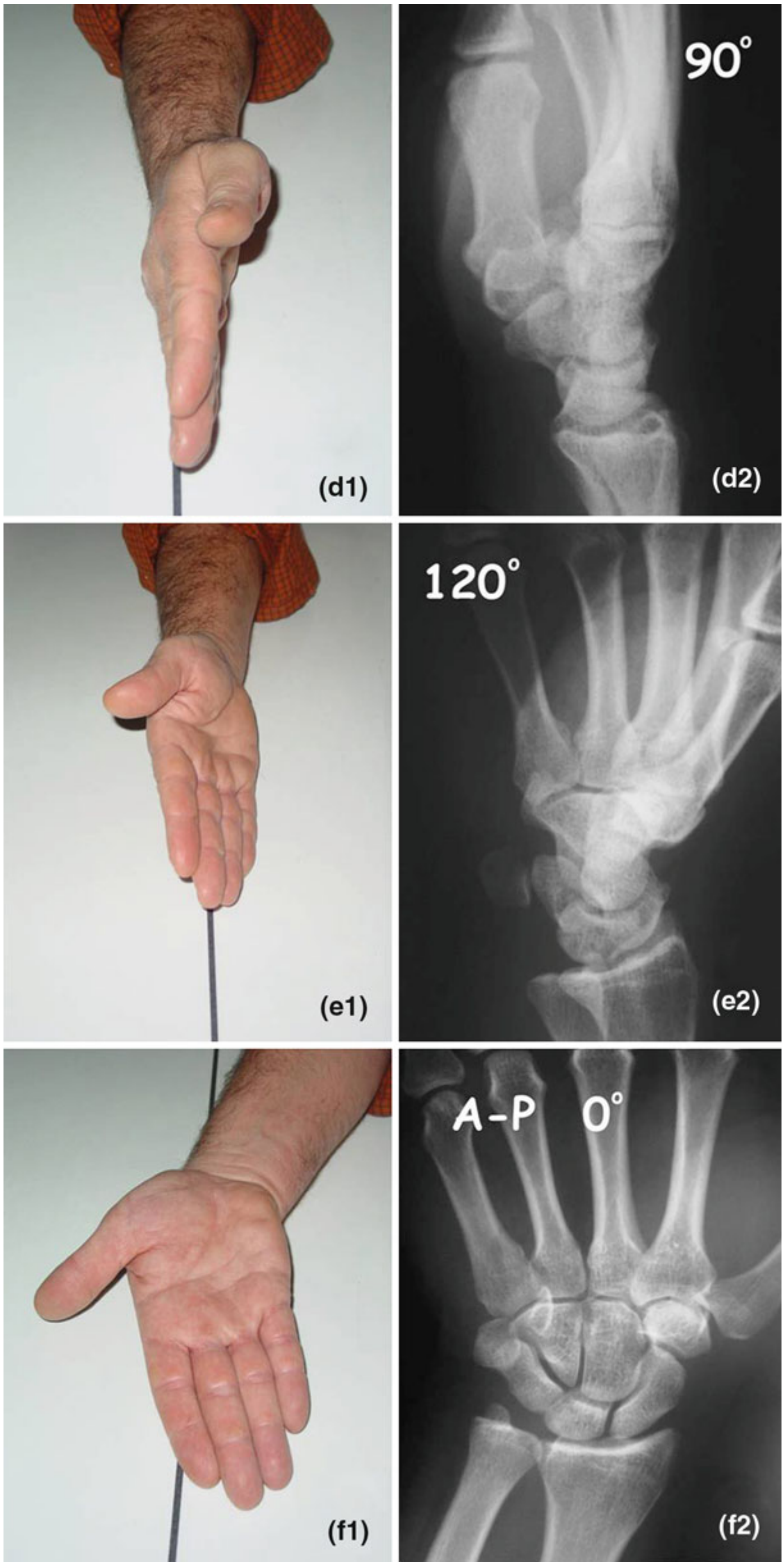


Fig. 9.7 **a1–f2** Six X-ray projections fully demonstrating the CMC joints. See text for description. With permission from [132]

Fig. 9.7 (continued)



of symmetry may escape the average orthopedic surgeon. He suggested four x-ray projections as being necessary for diagnosing injuries of the CMC joints, which are performed by gradual supination of the hand and wrist, starting with the hand flat and the wrist in neutral position. To the projections mentioned above we have added two more projections to fully demonstrate the CMC joints:

1. Posteroanterior (PA) view with the palm attached to the cassette and the wrist in neutral position. The 3 medial CMC joints should be demonstrated without bony overlap and with their articular surfaces parallel to each other (Fig 9.7 a1–a2).
2. Elevation of the radial side of the wrist by 30°. This position shows the 2nd, as well as the 1st CMC joints adequately (Fig. 9.7b1–b2).
3. Elevation of the radial side of the wrist by 60° clearly shows the lateral view of the 4th and 5th CMC joints (Fig. 9.7c1–c2).
4. Further rotation to a true lateral projection and with the wrist in neutral, is in fact, a true lateral view of only the 3rd CMC joint (Fig. 9.7d1–d2).
5. Further rotation of the wrist-hand unit by 30° beyond the lateral neutral position (120° from the starting position), is a suitable projection for the anteroposterior (AP) view of the 4th and 5th CMC joints (Fig. 9.7e1–e2).
6. Finally, an AP view with the dorsum of the wrist attached to the cassette, clearly demonstrates the 2nd to 4th CMC joints in AP direction (Fig. 9.7f1–f2).

Parkinson and Paton [59] identified an increase in the angle formed by the long axis of the 2nd and 5th MC on a true lateral radiograph. In cases of dislocation of the 5th CMC joint the CMC angle is increased compared to controls (38.5° compared to 9.8°). A lesser increase in the CMC angle is suggestive of subluxation of this joint.

The PA projection must be performed with the palm attached to the cassette, since substandard positioning results in overlapping of the articular surfaces. Normally, the articular surfaces of any joint must be parallel to each other and the width of the 2nd through 5th joint spaces is uniform measuring 1–2 mm. It's been supported that on the PA radiograph two parallel lines approximating the letter M (parallel M lines) can be consistently drawn to define the normal 2nd through 5th CMC bone relationships. A break in the parallel M lines suggests an abnormality at that site [60–62]. Fisher et al. [61] stated that in simultaneous 4th and 5th CMC joint dislocations, an overlap was observed only at the 5th CMC joint since the flexor and extensor carpi ulnaris draw the dislocated 5th metacarpal proximally.

McDonald et al. [63] calculated the angles between the index and small metacarpal shaft (I-S IMA) and between the long and small metacarpal shaft (L-S IMA) in a lateral radiograph, in patients with ulnar-sided CMC fracture-dislocations. They concluded that both angles are useful screening measurements if they are greater than 10°.

Chmell et al. [64] in the PA view demonstrated the importance of the oblique line through the metacarpal heads for the evaluation of the MC shortening, which accompanies a CMC joint dislocation. This line is drawn tangentially across the distal articular surfaces of the heads of the 3rd, 4th, and 5th metacarpals (Fig. 9.8).

Tomography or computed tomography (CT) scans can also be useful, particularly when there are concomitant injuries to the carpal bones [65].

9.6 Classification

Although a generally accepted classification does not exist, injuries of the CMC joints can be classified based on different parameters, such as:

1. The number of affected rays (isolated or multiple).
2. The direction of injury (dorsal, palmar, ulnar, divergent).
3. The type and severity of injury (sprain, subluxation, dislocation, fracture-dislocation).
4. The location of the injury (MC base fracture, trans-articular, fracture of the distal carpal row or combinations).

Fig. 9.8 The *oblique line* through the metacarpal heads (3rd to 5th), as described by Chmell et al. [64], for the evaluation of metacarpal shortening due to the 5th CMC joint fracture-dislocation (*arrow*). With permission from [132]

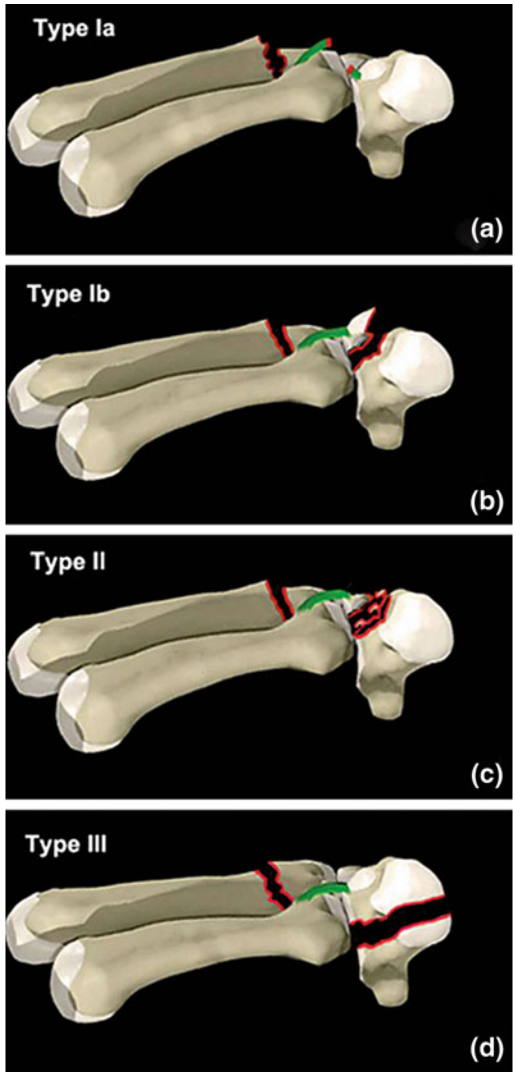


Fig. 9.9 Schematic depiction of Cain's et al. [23] classification, for injuries of the ulnar CMC joints (see text for details). With permission from [132]

Cain et al. [23] classified injuries of the ulnar CMC joints into 4 types based on the 5th CMC joint. This classification works on the basis that the primary injury is a fracture of the 4th metacarpal and the resulting shortening leads to the hamatometacarpal dislocation. In Type IA, subluxation or dislocation of the 5th MC is accompanied by dorsal CMC ligament disruption; in Type IB the dorsal dislocation of the 5th metacarpal is associated with an avulsion fracture of the dorsal rim of the hamate; in Type II a dorsal hamate comminution is present; and in Type III a coronal splitting of the hamate is present (Figs. 9.9a–d and 9.10a–d). The authors considered Type IB as the most frequent and correlated the type of injury to the stability. They regarded that Type II and III injuries, as grossly unstable requiring open reduction, while type I injuries were reduced, tested for stability and the treatment was adjusted accordingly. The main drawback of this classification is that it does not take into account the isolated dislocations of the 5th CMC joint without fracture of the 4th metacarpal.

However, since 4th and/or 5th metacarpal base intraarticular fractures are common findings that profoundly influence the treatment outcome, Lee et al. [30] recently suggested a new classification for the injuries of the ulnar CMC joints. This classification was based on the fractures of

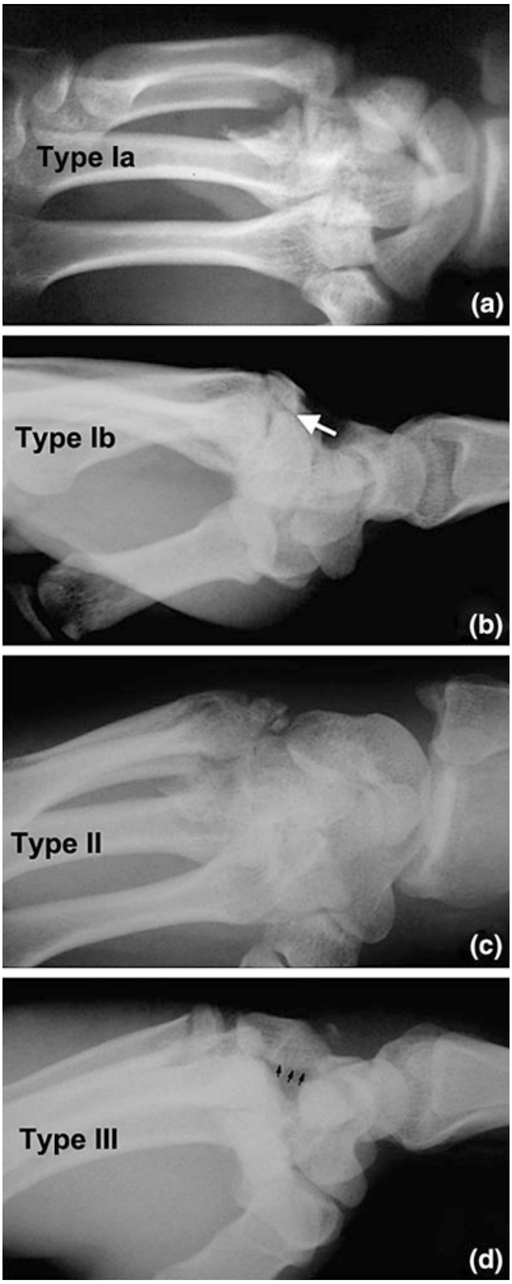


Fig. 9.10 Examples of ulnar CMC joint injuries according to the Cain et al. [23] classification. With permission from [132]

the bases of the 4th and/or 5th metacarpals and on the amount of articular surface of hamate fracture which was assumed as a fact. Three types of injuries were recognized: Type I was defined as less than one-third hamate articular surface involvement; Type II, more than one-third, and Type III, coronal splitting. Each type was divided into four subtypes: (1) absence of intraarticular MC base fracture; (2) fourth MC base fracture; (3) fifth MC base fracture; and (4) both fourth and fifth MC base fractures.

Garcia-Elias et al. [9] modified Cain's original classification system to include the radial two CMC joints and they moreover considered the stability of the injury following closed reduction as an important factor for classification. It is a common sense that prognosis of stable post-reduction injuries is much better than that of unstable injuries.

According to this classification there are three types of instabilities (Fig. 9.11a–h):

Type I (Transmetacarpal instability). Caused by fracture at the base of the metacarpal, which may be extrarticular (Ia) or intraarticular (Ib).

Type II (Carpometacarpal instability). Results after pure dislocation of the CMC joint (IIa) or a dislocation accompanied by a small chip avulsion fracture of the dorsal rim of the distal row carpal bones (IIb).

Type III (Transcarpal instability). This injury may involve only the dorsal and distal corner of the bone (IIIa) or it may be a fracture at the frontal plane of the bone affecting both the proximal and distal articulations (IIIb). Less frequently, the metacarpal along with the distal carpal row bone is dorsally subluxated with (IIIc) or without (IIId) fracture of the palmar surface of the bone. A case which could be classified as type IIId injury is illustrated in Fig. 9.12a–h.

This classification, has in addition a therapeutical importance, since type I (Ia and Ib) has been considered as a stable type and may be treated with longitudinal traction and cast support or percutaneous K-wires, while types II and III are inherently unstable and must be treated with open anatomical reduction.

It must be noted that delineation of these injuries using simple X-rays alone, is quite difficult. Tomography or CT scans at the sagittal plane are required.

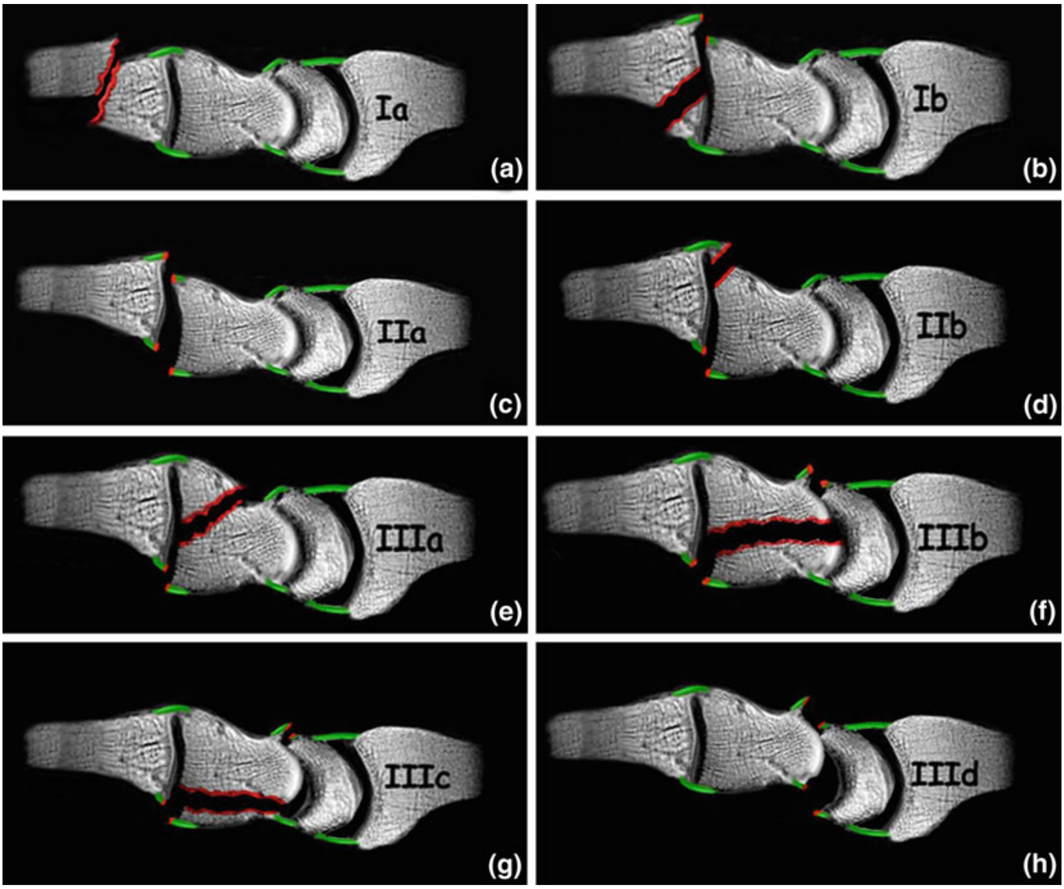


Fig. 9.11 Mayo Clinic's classification of CMC joint injuries, presented by Garcia-Elias et al. [9]. Although only the central column is depicted, it can be applied to all the affected rays. Type I injuries are considered as transmetacarpal, type II injuries as carpometacarpal, and type III injuries as transcarpal instability. With permission from [132]

9.7 Acute Injuries of the CMC Joints

Since acute injuries of the CMC joints are frequently the result of high-energy trauma, injuries to other parts of the body or even life-threatening injuries could probably coexist. In addition, complex injuries located at different levels of the same wrist (CMC, intercarpal, radiocarpal) have also been described [66, 67].

Almost every possible combination of injuries has been reported, including the divergent dislocation with some metacarpal bases being dorsally, while others being palmarly dislocated [19, 43, 68–71] (Fig. 9.13a–g). The divergence may have a different location in each case. In some cases, the divergence is localized and involves only two metacarpal bases, e.g., between 4th and 5th CMC joints [46, 72–74], while occasionally all the metacarpal bases are affected and the divergence could be located between the 2nd and 3rd [19, 43] or between the 3rd and 4th [68, 69] metacarpal bases.

Frick et al. [75] in a retrospective study of 100 CMC dislocations found that in half the cases, lesions were located only within the 5th ray, while carpal or metacarpal fractures were associated with the majority of cases (88 %).

The most common of all CMC joint injuries is considered to be the isolated injury of the 5th CMC joint, which is followed by the

Fig. 9.12 Male, 46 years old. Five months prior to his examination he reported a left wrist injury, due to its entrapment in a garbage bin in hyperpronation position. He remained undiagnosed. Restriction of dorsal wrist extension, as well as painful osseous swelling at the dorsal side of the wrist, were noted during examination (**a**, **b**); radiological control revealed a widening of the lunocapitate joint in the P-A view (*arrows*) (**c**) and a dorsal midcarpal subluxation in the L view (**d**); MRI did not indicate further damage (**e**); dorsal approach revealed a fixed dorsal subluxation of the distal carpal row (**f**) (*C* Capitate, *L* Lunate, *S* Scaphoid); due to the difficulties of reduction and despite the good condition of the capitate head's cartilage, the patient was subjected to a scapholunocapitate fusion; the postoperative X-rays (**g**, **h**); the radiological result 1 year later (**i**, **j**). This case was considered as type IIId injury according to Mayo Clinic classification [9]

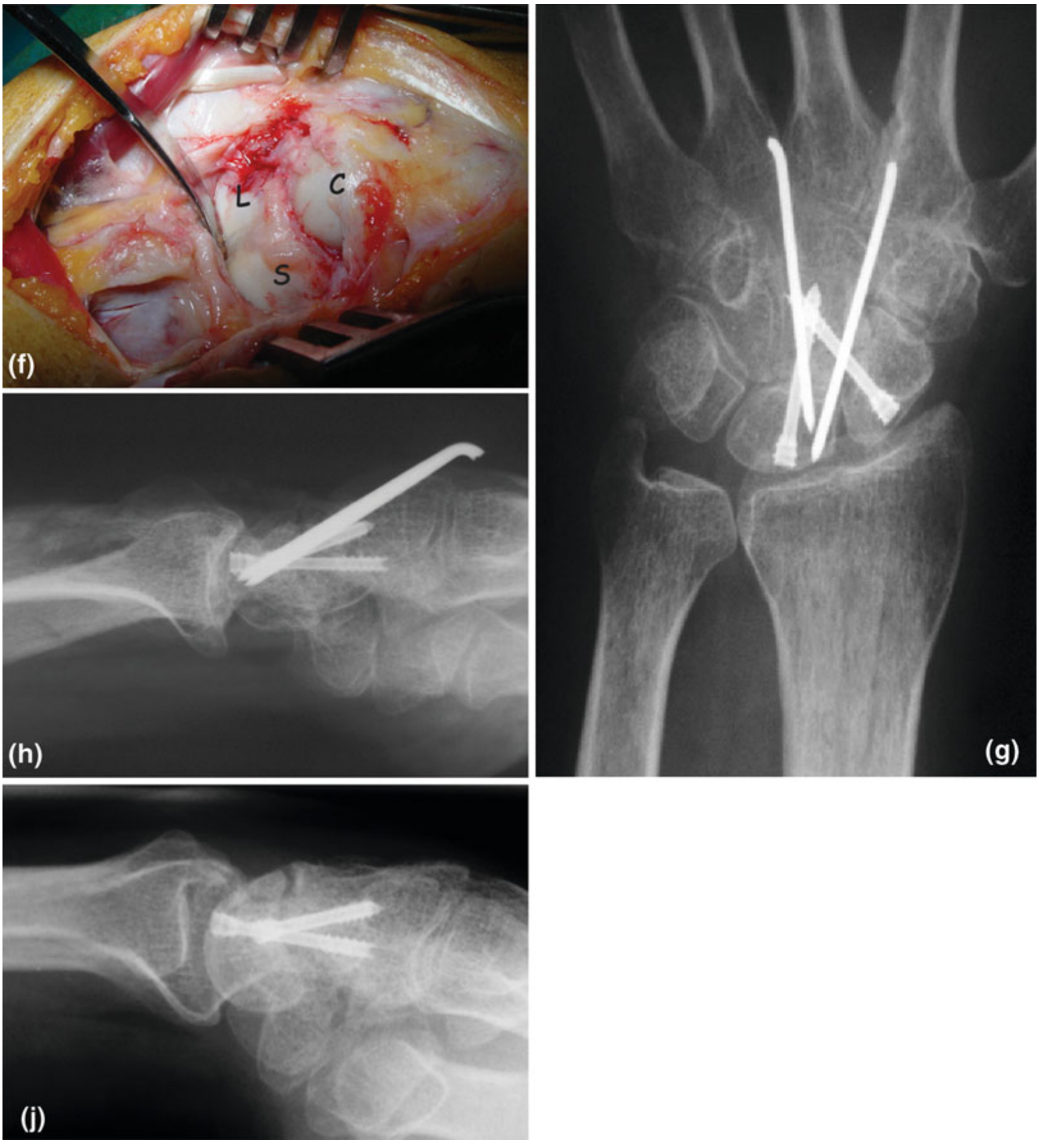


Fig. 9.12 (continued)

simultaneous injury of the 4th and 5th CMC joints (Fig. 9.14a–d).

The early recognition of these injuries is essential for satisfactory outcomes. The disability of the hand is severe in untreated cases or in those where treatment is delayed.

Management options include closed reduction and cast immobilization, closed reduction and K-wire fixation, or open reduction and internal fixation. The choice of treatment depends on the severity and stability of the CMC joints and the expertise of the attending physician [10].

9.7.1 Localized Injuries

Excluding the thumb, the most frequently injured CMC joints are the bases of the ring and small fingers, frequently described as hamato-metacarpal fracture-dislocations [9, 23, 35, 76].

Fig. 9.13 Male, 28 years old, car accident. Divergent dislocations with the 2nd and 3rd metacarpals being dorsally dislocated, while the ulnar metacarpals were volarly displaced (**a**, **b**, **c**). With two longitudinal skin incisions dorsally, the dislocations were reduced and stabilized with K-wires (**d**, **e**); final radiographic appearance 6 months later (**f**, **g**). With permission from [132]

A limited number of pure dislocations of the 4th to 5th MC in dorsal [26, 61, 77, 78] (Fig. 9.15a, b) or in volar direction [49] or of a divergent type in different directions [46, 72–74] have been reported. Another rare combination of injuries is the coronal fractures of the body [29] or the dorsal pole of the hamate [25, 31, 76, 79–83] associated with injuries of the bases of the 4th and/or the 5th CMC joints (Fig. 9.16a–g).

The most frequently affected isolated CMC joint is the 5th, which is mainly characterized as a dorsal fracture-dislocation. The displacement is analogous to a Bennett's fracture of the thumb. Despite the fact that 4 types of intraarticular fractures at the base of the 5th MC have been described [33], the most common type involves a radiovolar bone fragment of different size, which remains attached with the 4th metacarpal through the intermetacarpal and palmar CMC ligaments, while the remainder of the 5th metacarpal is displaced ulnarly and dorsally to a varying degree, due to the action of extensor carpi ulnaris and the opponent digiti minimi muscle (Fig. 9.17a, b).

Fig. 9.13 (continued)

In addition, there are reported cases of isolated dislocations of the 5th CMC in dorsal [28, 84–88], or more rarely, in volar direction [45, 48, 60, 89] (Fig. 9.18a, b). There are two types of volar dislocations: radial and ulnar. In the radial type, which is the most common, all of the ligamentous and tendinous attachments are torn and usually open reduction is required using a volar-ulnar surgical approach. In the ulnar type, the pisometacarpal ligament remains intact preventing excessive displacement of the fifth metacarpal, which however overlaps the hamate and shortens the digit, due to the action of the flexor and extensor carpi ulnaris and the hypothenar muscles. Sometimes, the intact pisometacarpal ligament prevents excessive displacement, thus rendering stress radiographs necessary for correct diagnosis [89]. In this type of injury, the problem is usually not the reduction itself, but rather maintaining the reduction [6], thus percutaneous K-wire fixation of the joint is necessary.

Closed reduction is accomplished with local or general anesthesia, longitudinal traction of the finger(s), direct pressure at the bases of the affected metacarpals and dorsal extension of the head of the MC, if the most common dorsal dislocations of the CMC joints are considered. Although successful stabilization of the wrist after the reduction has been suggested only with plaster [7, 90, 91], most authors advocate using percutaneous K-wires fixation. K-wires are percutaneously inserted from the base of the metacarpal to the hamate or the adjacent 4th metacarpal, from the dorsal and ulnar surface of the wrist, while taking care not to disrupt the function of the extension mechanism. Recently, Mozaffarian et al. [92] described a safe corridor for pinning of the 5th CMC joint to prevent iatrogenic injury to the ulnar nerve and tendons;

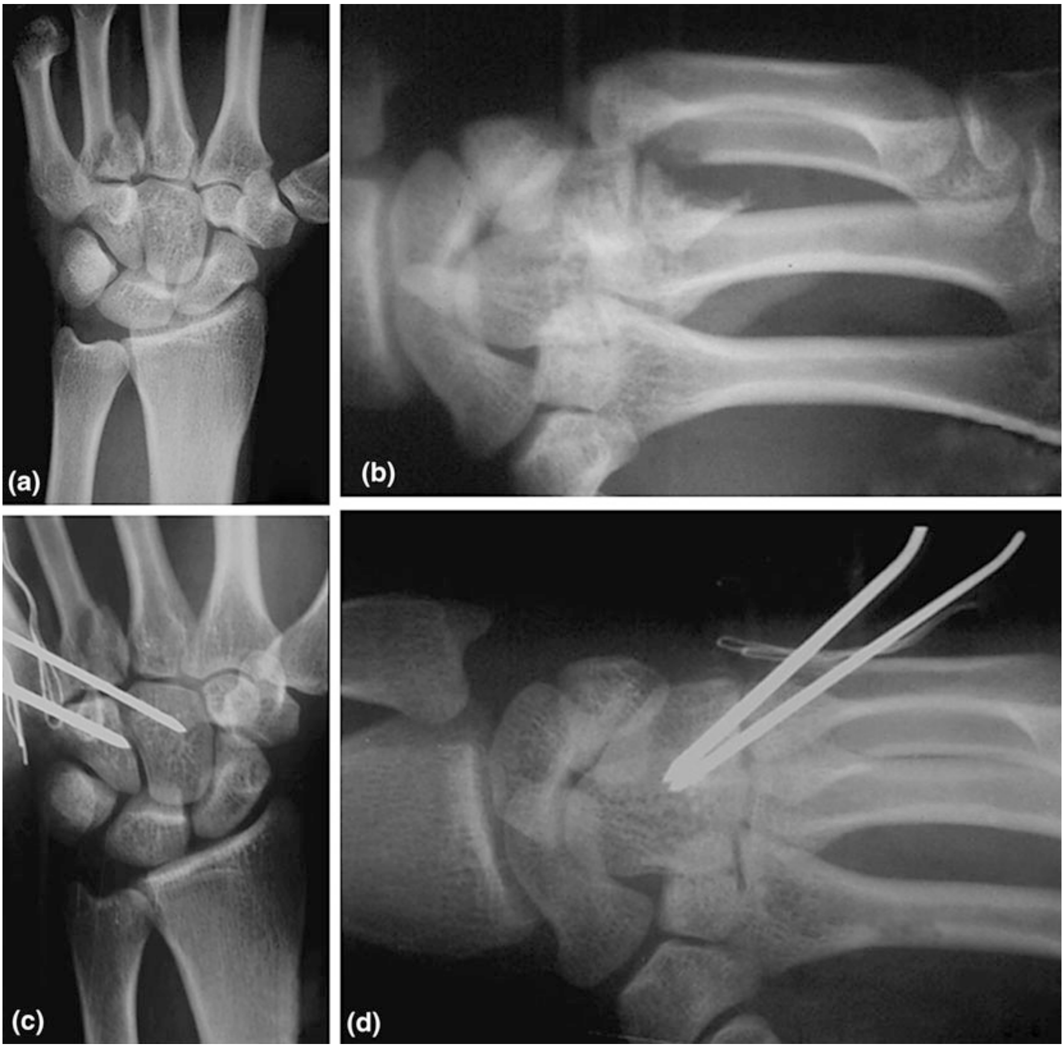


Fig. 9.14 Case with fracture of the base of the 4th metacarpal and dislocation of the 5th CMC joint (**a**, **b**); closed reduction and percutaneous fixation with K-wires (**c**, **d**). With permission from [132]

it is located 2 cm distal to the joint at an angle of 20°–30° to the coronal plane, from 10° volar to dorsal to 20° dorsal to volar direction in the saggital plane. Once stable reduction has been achieved, a direct, active, and passive mobilization of the fingers and wrist must commence within 1–2 weeks. The K-wires will be maintained for at least 6 weeks, although keeping them for up to 12 weeks has also been suggested [11]. After the K-wires are removed, the patient starts grip strengthening exercises. The importance of early controlled mobilization has been emphasized [93] for reducing postinjury complications (stiffness of hand joints, tendon adhesions, and intrinsic muscle weakness).

Slutsky [94] described an arthroscopic technique for reduction and percutaneous fixation of 5th CMC fracture-dislocations. The technique is considered useful especially in cases where the articular fracture fragment is volar and difficult to visualize and reduced using a dorsal approach.

Rarer are the isolated injuries of the 2nd and/or 3rd CMC joint. In literature there are reported cases of dorsal [36, 95–97] or palmar dislocation

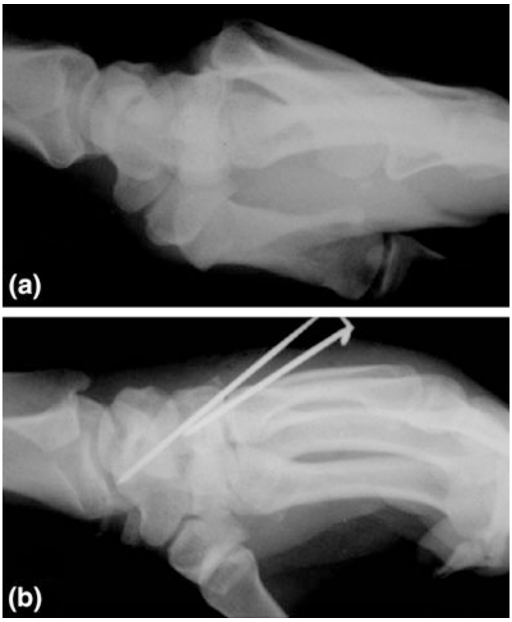


Fig. 9.15 Pure dorsal dislocations of the ulnar CMC joints (**a**), treated with closed reduction and stabilization with two K-wires (**b**). With permission from [132]

[98, 99] of the 2nd CMC joint, dorsal nonreducible dislocation of the 2nd CMC joint due to interference of the extensor carpi radialis brevis [100, 101] and finally, palmar dislocations of the 2nd to 3rd CMC joint [12, 42, 58]. Although K-wire fixation is recommended to prevent recurrent dislocation, it has been suggested that it is not always necessary because of the intrinsic stability of the joint [101].

Open reduction and internal fixation, are clearly indicated in the following cases:

1. Unsuccessful closed reduction.
2. Irreducible dislocations due to interposed soft tissue or fracture fragments.
3. In cases of delayed diagnosis, where the contraction of soft tissues hinders closed reduction.
4. Complex fracture-dislocations.

Incision of the skin for the isolated injury of a CMC joint is usually dorsal curvilinear or of S type, with the transverse part of the incision located above the joint.

9.7.2 Multiple Injuries

In general, multiple injuries of the CMC joints cause significant swelling of soft tissue that obstructs closed reduction, which even if achieved, is difficult to maintain. The inability to achieve closed reduction is sometimes due to interposed joint capsule in the CMC joints [102]. There have been reported cases of dislocations or fracture-dislocations of all five CMC joints [103–112], dorsal dislocations of the 2nd to 5th CMC joint [22, 54, 67, 102, 113–118] (Figs. 9.19a–d and 9.20a–d), palmar dislocations of the 2nd to 5th CMC joint [90, 119–121], palmar dislocations of the 2nd to 4th CMC joint [122], or fracture of the base of the 3rd and dorsal dislocations of the 4th and 5th CMC joints [51].

Garcia-Elias [2] stated that the treatment of choice for the relatively stable type II injuries (according to his classification) is early closed reduction, distal-to-proximal pin fixation, and specific cast support. Types I and III, by contrast, because of the presence of a displaced intraarticular fracture, are inherently unstable, thus open treatment, which allows identification and treatment of small osteochondral fractures, debridement of debris in the joints, accurate reduction and proper stabilization, is the method of choice. Rare cases have been reported with coronal fractures through the capitate and hamate [123] or through the capitate, hamate, and trapezoid [124], both of which necessitated a CT-scan for diagnosis. Both these cases probably constitute a type IIIb injury (according to Garcia-Elias classification) and were treated with open reduction and internal fixation.

A major distal carpal row bone fracture is frequently associated with CMC dislocations [9, 125] and in such cases open reduction and fixation of the fractured bone with K-wire(s) or with a compression screw is considered the treatment of choice (Fig. 9.21a–f).

The dislocated joints are usually approached from the dorsal side and the skin incision may be longitudinal [17, 126] or transverse [46, 50, 69,

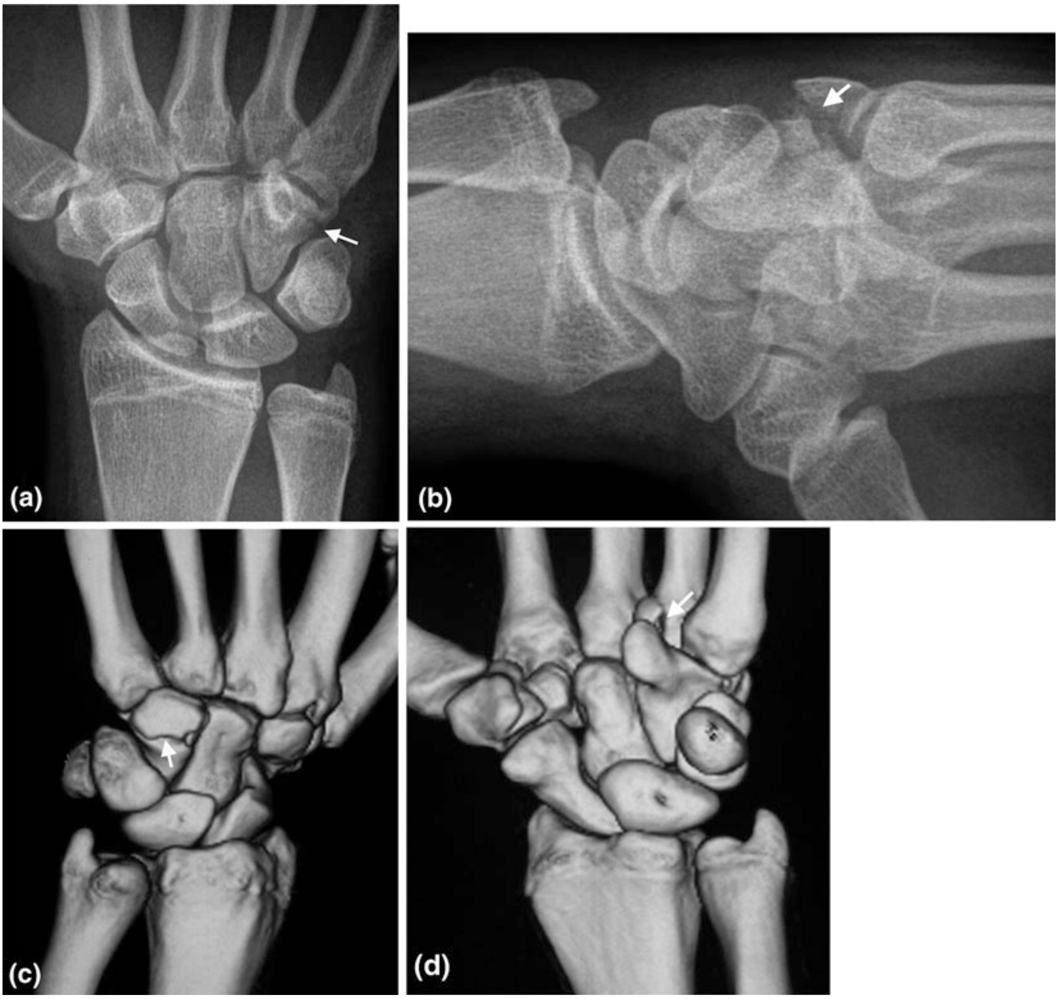


Fig. 9.16 Male, 15 years old. Subluxation of the 5th CMC joint with a coronal fracture of the dorsal pole of the hamate (**a**, **b**); 3D CT-scan reconstruction images disclosed the extent of the injury (*arrows*) (**c**–**d**), while CT images disclosed the fracture of the hamate (*arrows*) (**e**–**f**) and in addition a fracture of the volar base of the 4th metacarpal (*arrow*) (**g**). The patient refused any further treatment

70, 115]. Alternatively, we may approach all 4 bases of the metacarpals, using two longitudinal skin incisions (between 2nd to 3rd and 4th and 5th CMC joint). Cutaneous nerves are protected and the extensor tendons are retracted to gain access to the dislocated joints. Reconstruction of the transverse carpal row starts with the reduction and stabilization of the base of the 3rd [6, 10, 39, 43, 121] or of the 2nd [67] metacarpal. When all 4 metacarpals are dislocated, stabilization of each joint separately is not necessary, as some of the interosseous ligaments usually remain intact, which helps to stabilize the adjacent metacarpal [3, 6, 68]. The wires must be placed so as to avoid the extensor tendons, since early mobilization is desirable.

The pins are removed at 4–6 weeks postoperatively. An alternative method to stabilize the dislocated joints with K-wires, avoiding the risk of damaging tendons and nerves, is the

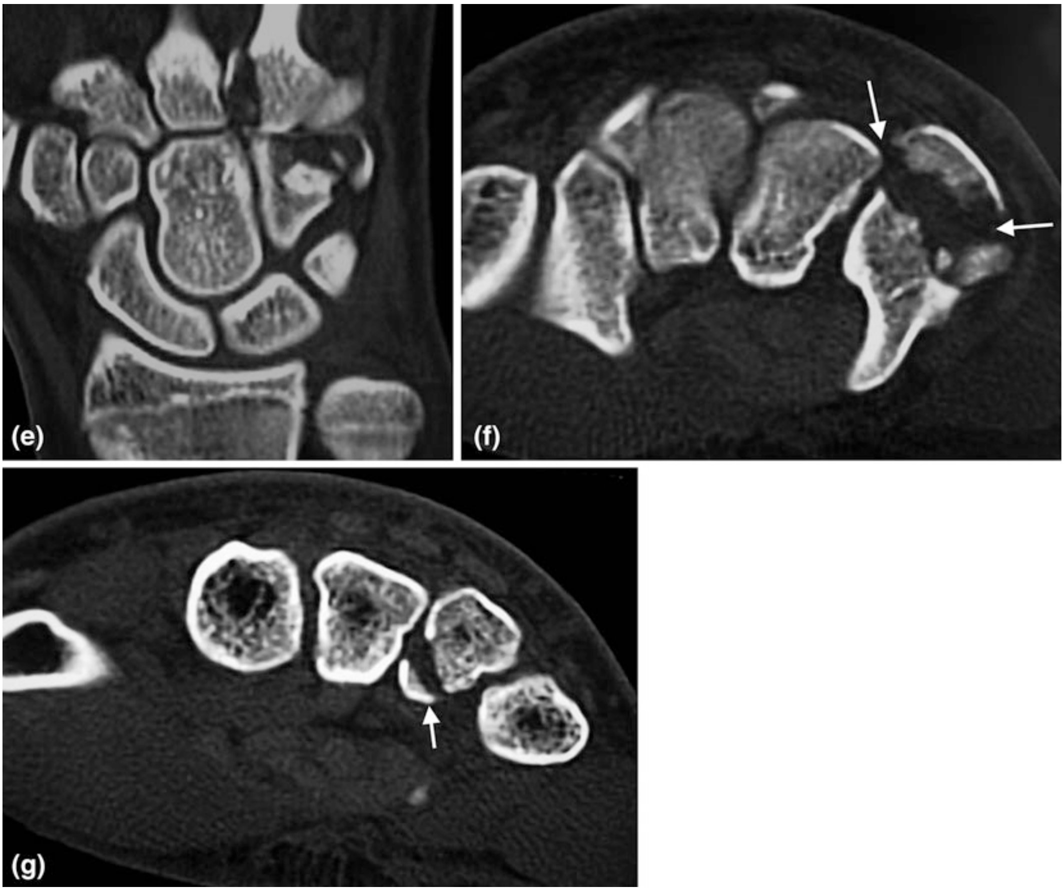


Fig. 9.16 (continued)

technique proposed by Foster [26], called "intramedullary stress sharing fixation" (originally described for ulnar CMC joints' dislocations) (Fig. 9.22a–d).

9.8 Chronic Injuries of the Carpometacarpal Joints

There is no consensus for the definition of a chronic CMC dislocation. Most authors believe that an injury dated more than 3 to 6 months is defined as chronic [17, 127], while Ahmad and Plancher [128] defined CMC dislocations as chronic when there is a delay in diagnosis and treatment of at least 6-12 weeks. Usually, chronic cases are expressed with deformity, localized sensitivity, reduced muscle strength and in the long term, symptoms of arthritic changes (Figs. 9.23a, b and 9.24a–g).

Although there had been early reports that chronic dislocations or subluxations of the CMC joints do not result in any disability [1, 68], this view today has no advocates. Green [129] supported that injuries more than 3 weeks old do not require any treatment.

In cases with mild symptoms such as slight residual subluxation, conservative treatment is probably best [17], while in cases with marked deformity an attempt for delayed open reduction could be successful as late as 3–6 months postinjury [38]. Imbriglia [127] reported successful open reduction of the 2nd to 5th CMC joints 3 months post injury without the need for arthrodesis, due to

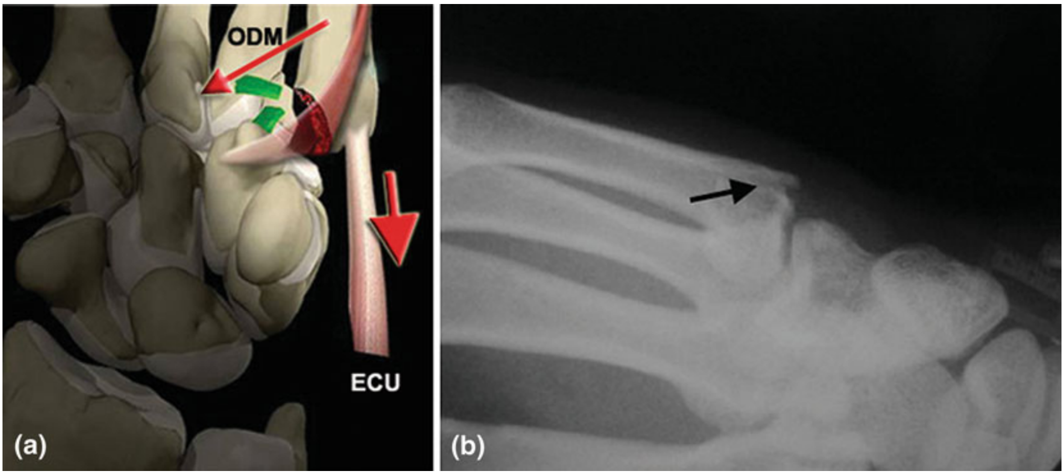


Fig. 9.17 The most common type of fracture-dislocation of the 5th CMC joint. A small ulnovolar bone fragment remains attached to the 4th metacarpal through the ligaments, while the 5th metacarpal is ulnarly and dorsally displaced due to the action of ECU tendon and the direction of pull by the hypothenar muscles (*ODM* Opponent digiti minimi) (**a**); a clinical analogue of the injury (**b**). With permission from [132]

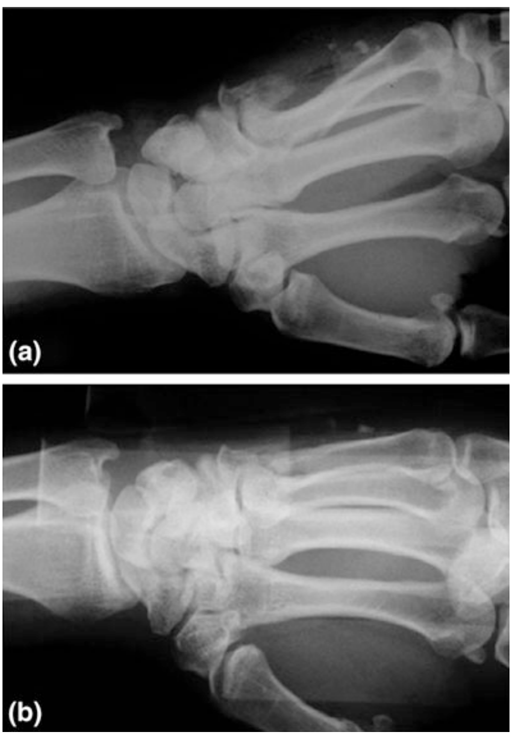


Fig. 9.18 Rare volar fracture-dislocation of the 5th CMC joint (**a**), which was treated with closed reduction (**b**). With permission from [132]

the integrity of the articular cartilage. Prokuski and Eglseder [67] stated that delay of up to 4 weeks did not adversely affect results.

In any case, regardless of the time elapsed, the management will depend on the complaints, while if operative treatment is needed, the appropriate method will depend on the reducibility of the CMC joints, and the condition of articular cartilage.

9.9 Long-Term Results

Few reports document long-term follow-up in cases of multiple carpometacarpal dislocations. However, it is uniformly accepted that with early diagnosis and prompt treatment with restoration of normal anatomical reduction, excellent results may be expected [9, 10, 35, 41]. In addition, the outcome has generally been favorable as long as the reduction is maintained.

It has been suggested [10, 121] that delayed diagnosis and treatment will usually result in an undesirable outcome of pain, reduced grip strength and degenerative arthritis and that up to

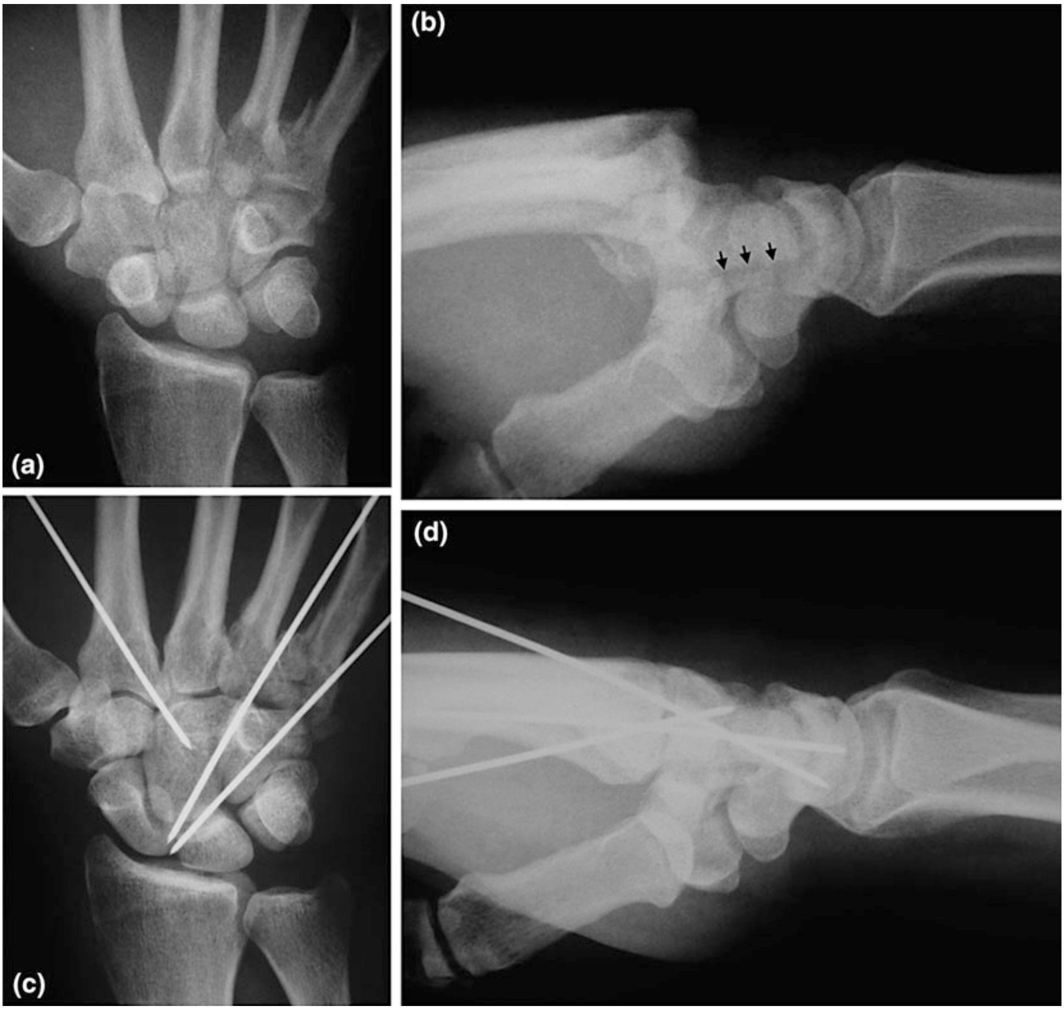


Fig. 9.19 A case of dorsal dislocations of the 2nd to 5th CMC joints associated with a fracture of the volar part of the capitate (*arrows*) (**a**, **b**); it was treated with open reduction and fixation with K-wires (**c**, **d**). With permission from [132]

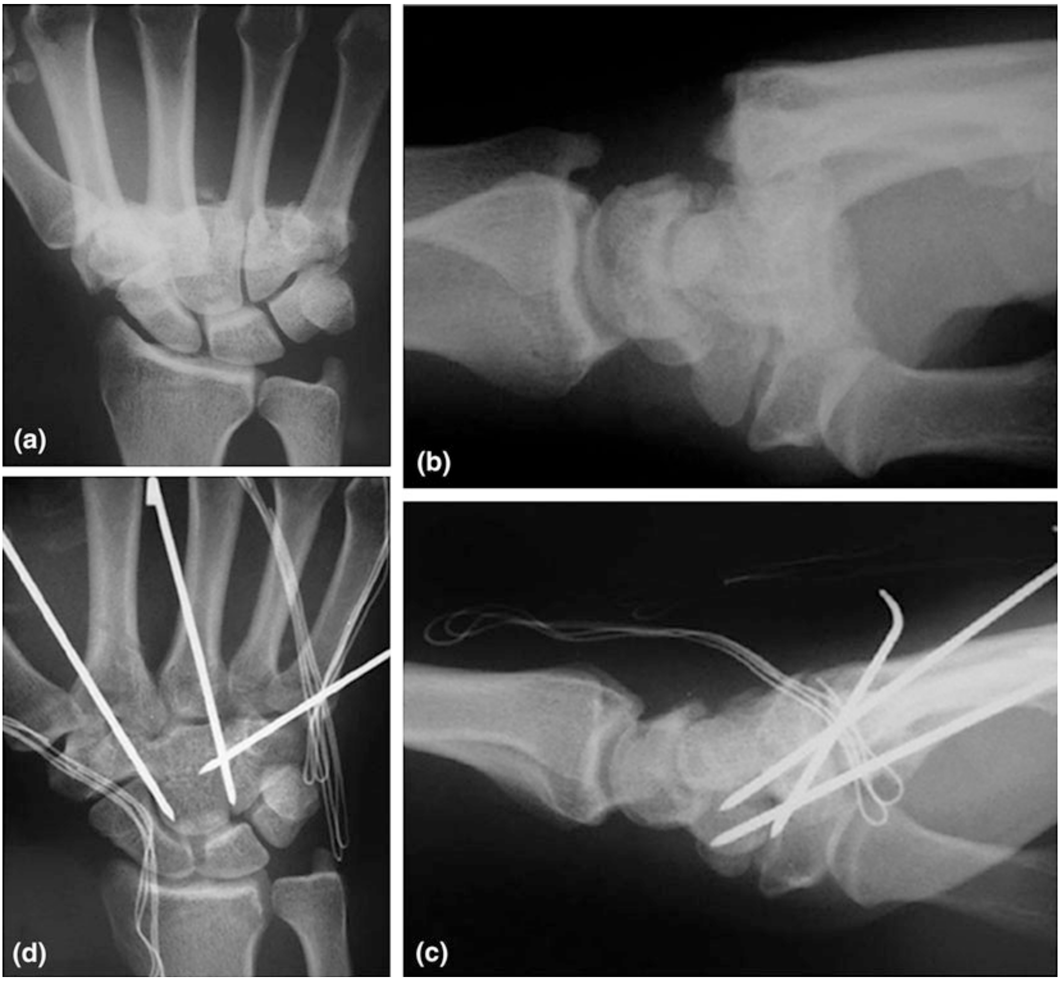


Fig. 9.20 Male, 40 years old, motorcycle accident. Dorsal dislocations of the 2nd to 5th CMC joints (**a**, **b**); he was treated with closed reduction and K-wires insertion, while the 4th CMC joint was reduced coincidently with the 3rd CMC joint (**c**, **d**). With permission from [132]

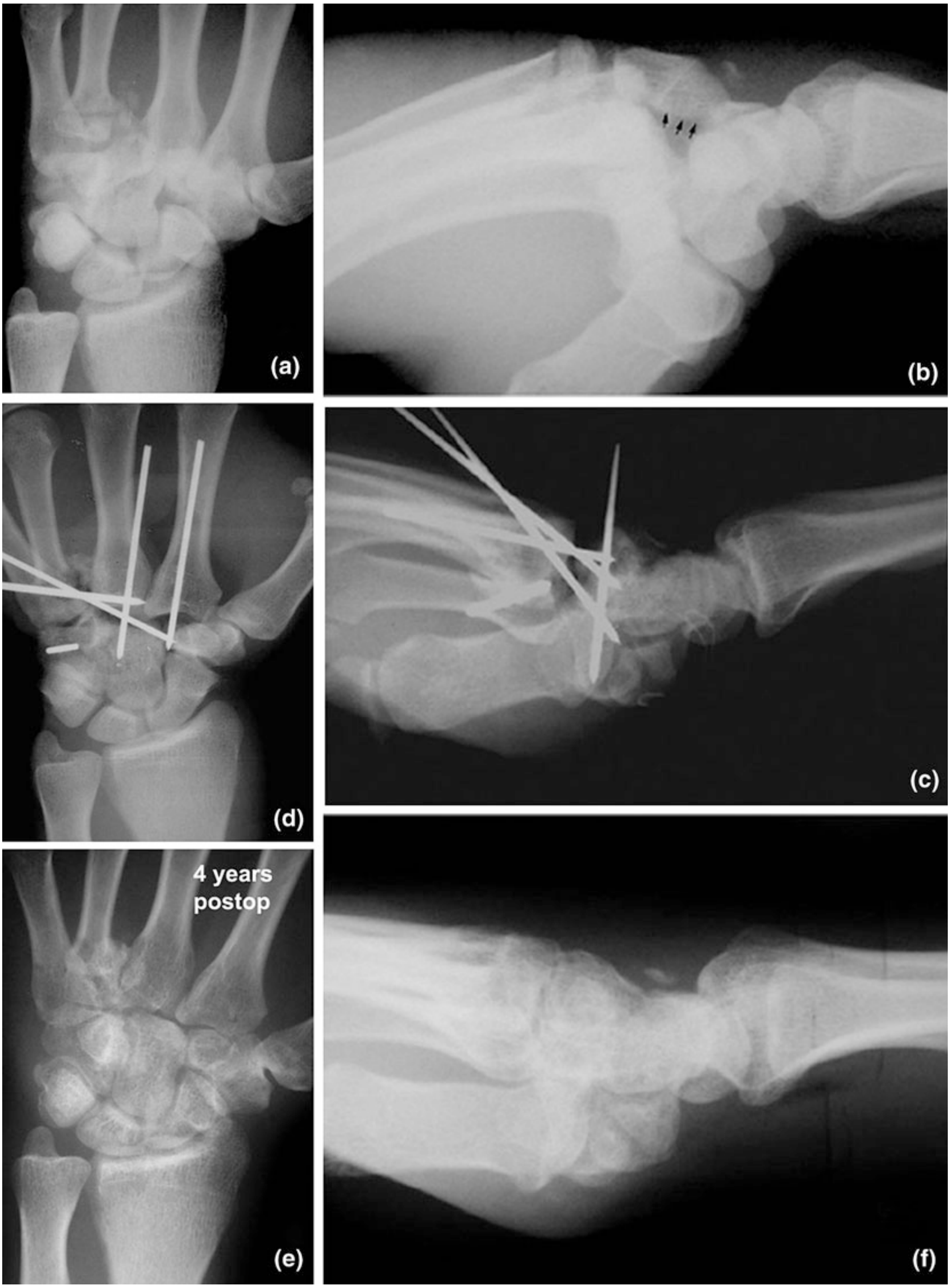


Fig. 9.21 Male, 30 years old, motorcycle accident. Dorsal dislocations of the 2nd to 5th CMC joints. The injuries of the 2nd and 3rd CMC joints were of IIa type, that of the 4th CMC joint was of Ia type and that of the 5th CMC joint was of IIIb type (associated with a fracture of the body of the hamate in the coronal plane) (*arrows*), according to the Mayo classification (**a**, **b**); he was treated with open reduction and K-wires stabilization including the hamate fracture (**c**, **d**); final radiographic appearance 4 years later (**e**, **f**). With permission from [132]

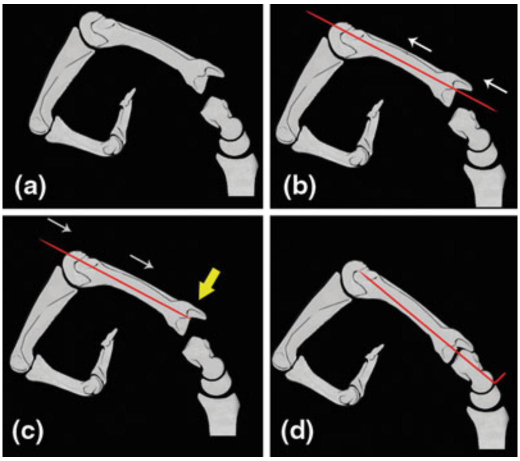


Fig. 9.22 Fosters' [26] stabilizing method of a dislocated CMC joint using intramedullary K-wire: the dislocated joint (**a**); insertion of the K-wire from the proximal to the distal side into the intramedullary canal, exiting dorsally at the flexed MP joint and through the central portion of the extensor tendon (**b**); reduction of the dislocation and proximally advancing of the K-wire into the corresponding bone of the distal carpal row after excessive wrist palmarflexion (**c**); the pin is withdrawn proximally to disengage the head of the metacarpal; its proximal portion is curved and cut below the skin level (**d**)

43 % of patients with neglected single CMC joint injuries will experience residual pain and impaired function. However, with appropriate management, up to 87 % of patients with CMC joint injuries will return to full work and sporting activities with negligible pain.

Gunther [3] stated that open reduction with K-wire fixation results in excellent hand function. Grip strength returns to normal and the only residual symptoms of the fracture-dislocation are usually mild aching during changes of weather or during extremely heavy work.

Garcia-Elias et al. [9] reported that patient satisfaction when treated in the acute phase is high; on the contrary, delayed treatment, even with bone grafting and stabilization until fracture consolidation, had an increased incidence of mild residual symptoms, including weakness of grasp or pinch and tenderness at the CMC area. In addition, delayed diagnosis may lead to fracture nonunion due to vascular or mechanical factors, with adverse consequences (muscular imbalance, reduced grip strength, and arthritis).

Lawlis and Gunther [70] suggested that most adverse results concern patients with 2nd and 3rd MC injuries or those having additional injury of the ulnar nerve.

Lundeen and Shin [33] reported clinical results of 22 patients with intraarticular fractures of the base of the 5th MC treated by closed

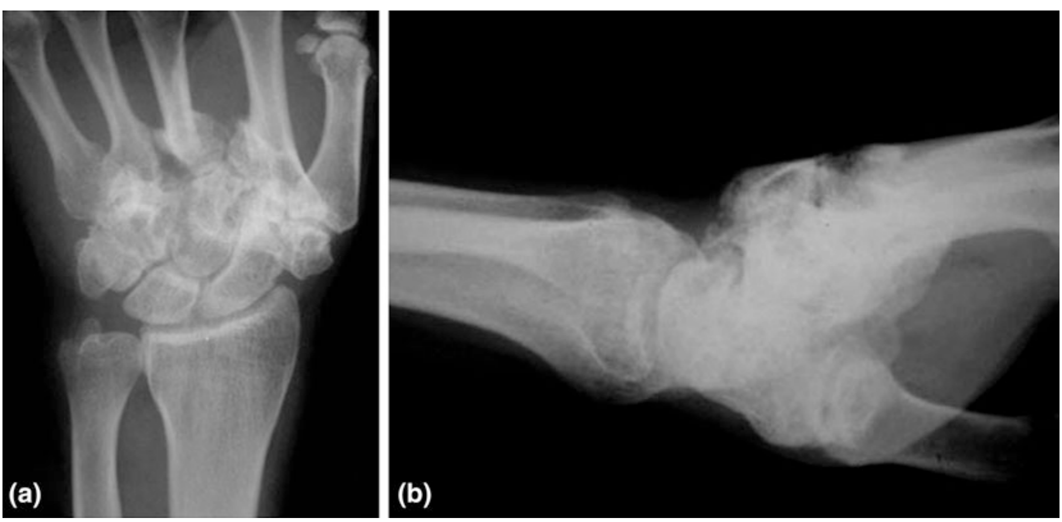


Fig. 9.23 Neglected dorsal CMC fracture-dislocations (**a**, **b**). The patient complained for dysfunction of the extensor tendons. With permission from [132]

reduction and cast immobilization. After an average follow-up of 43 months, twenty patients reported excellent or good results and two reported fair or poor results. Nine of those patients (41 %) had mild arthrosis of the CMC joint. Yildiz et al. [112] supported that mild degenerative changes in the CMC joints may be present radiographically on long-term follow-up. However, the functional results appear to be good, provided that open reduction and internal fixation of the dislocations have been achieved.

9.10 Arthrodesis of CMC Joints

In cases of chronic instability or post-traumatic arthritis of CMC joints not responding to conservative treatment, arthrodesis constitutes the operation of choice [6, 50]. Arthrodesis of the 2nd, 3rd or both CMC joints does not result in any functional deficiency, because the motion range of these joints is limited, while the method has been suggested as a primary treatment for unstable fracture-dislocations [50, 70, 126]. In addition, the need for CMC arthrodeses tends to be higher among patients with more associated injuries [67]. Even arthrodesing the mobile 4th and 5th CMC joints will not cause any problems, provided that the joints are fused in sufficient flexion to maintain the normal curvature of the distal metacarpal arch when making a fist [6]. Because mobility of the 5th CMC joint is greater than the 4th, it should be fused in greater flexion. Arthrodesis is performed with the use of a sliding inlay graft, an iliac strut graft or a corticocancellous graft from the distal radius, which is stabilized with K-wires (Fig. 9.25a–g). Fusions usually heal within 8 weeks. As an alternative to arthrodesis, resectional arthroplasty with interposition of a rolled tendon spacer has been applied [130] or if the 5th CMC joint is involved, a "stabilized arthroplasty" suggested by Dubert and Khalifa [131] can be applied. The latter technique is based on the resection of the base of the 5th metacarpal, whereas the length of the fifth digit ray is restored by fusion to the adjacent 4th metacarpal.g

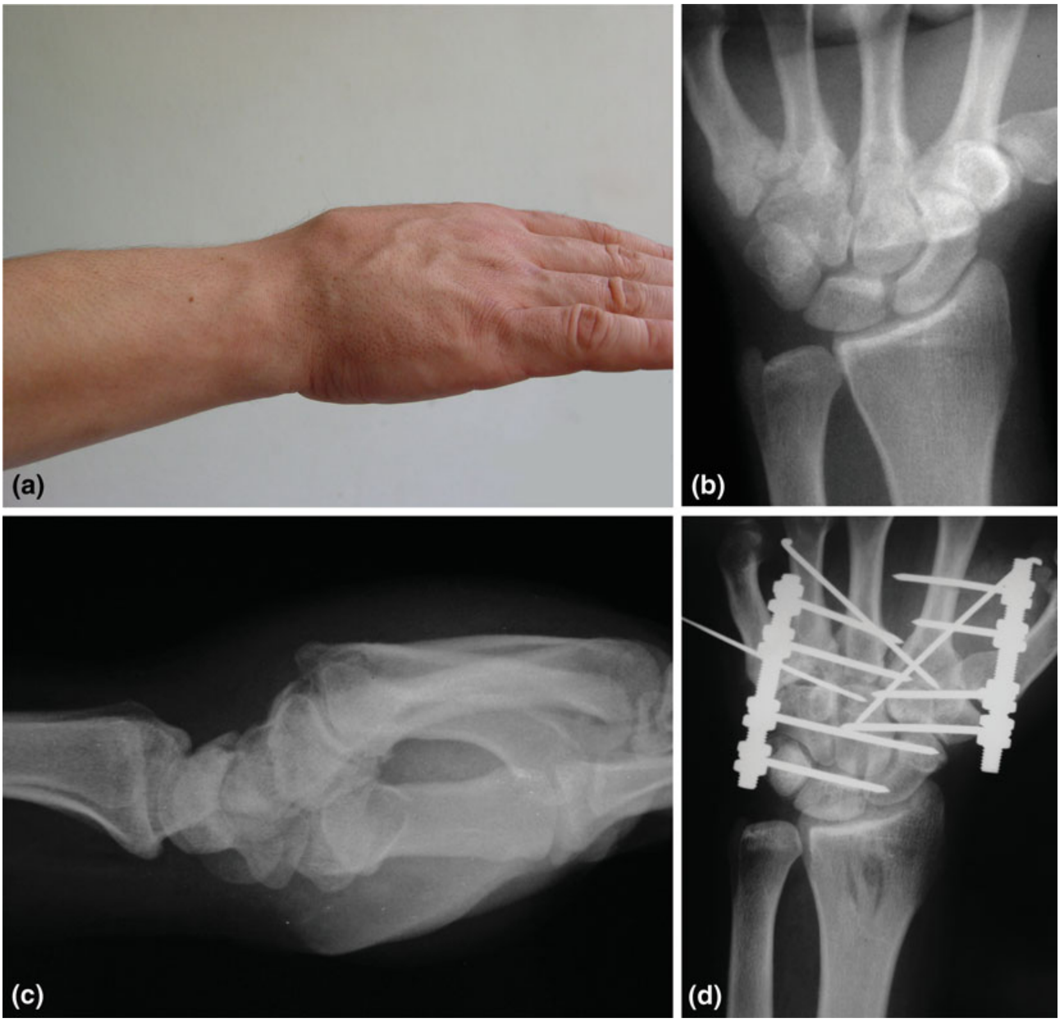


Fig. 9.24 Male, 29 years old, with a painful osseous swelling at the dorsal side of the wrist (**a**); radiographs revealed old unreduced dorsal dislocations, mainly of the 2nd to 3rd CMC joints (**b**, **c**); for the fusion of the affected joints and to regain the length of the shortened metacarpals, two small external fixators were used (**d**, **e**); radiographic appearance after the hardware removal (**f**, **g**)

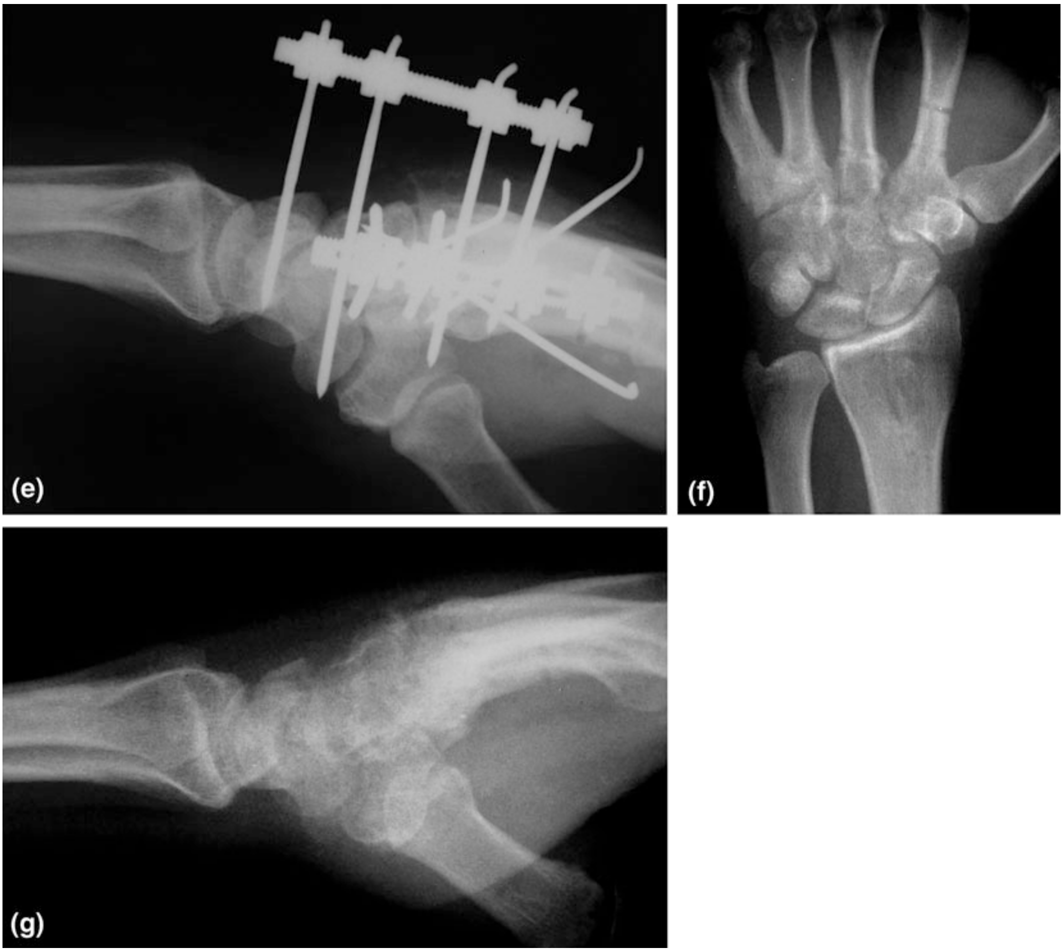


Fig. 9.24 (continued)

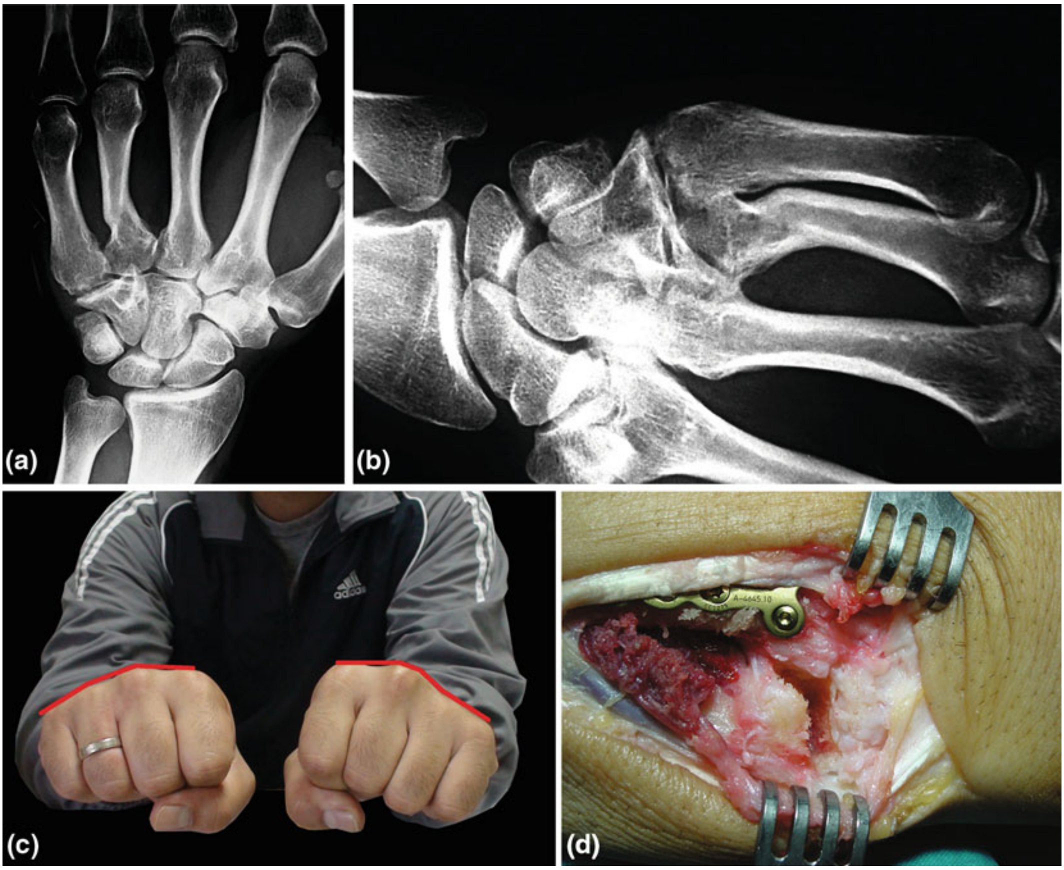


Fig. 9.25 Male, 35 years old, with a two-year-old malunion of the proximal 4th metacarpal, with arthritic changes of the dorsally subluxated 5th CMC joint (**a**, **b**); the disruption of the normal curvature of the metacarpal heads when making a fist, is showed (**c**); corrective osteotomy of the 4th metacarpal using a small plate and fusion of the 5th CMC joint (**d**, **e**); postoperative X-rays (**f**, **g**)

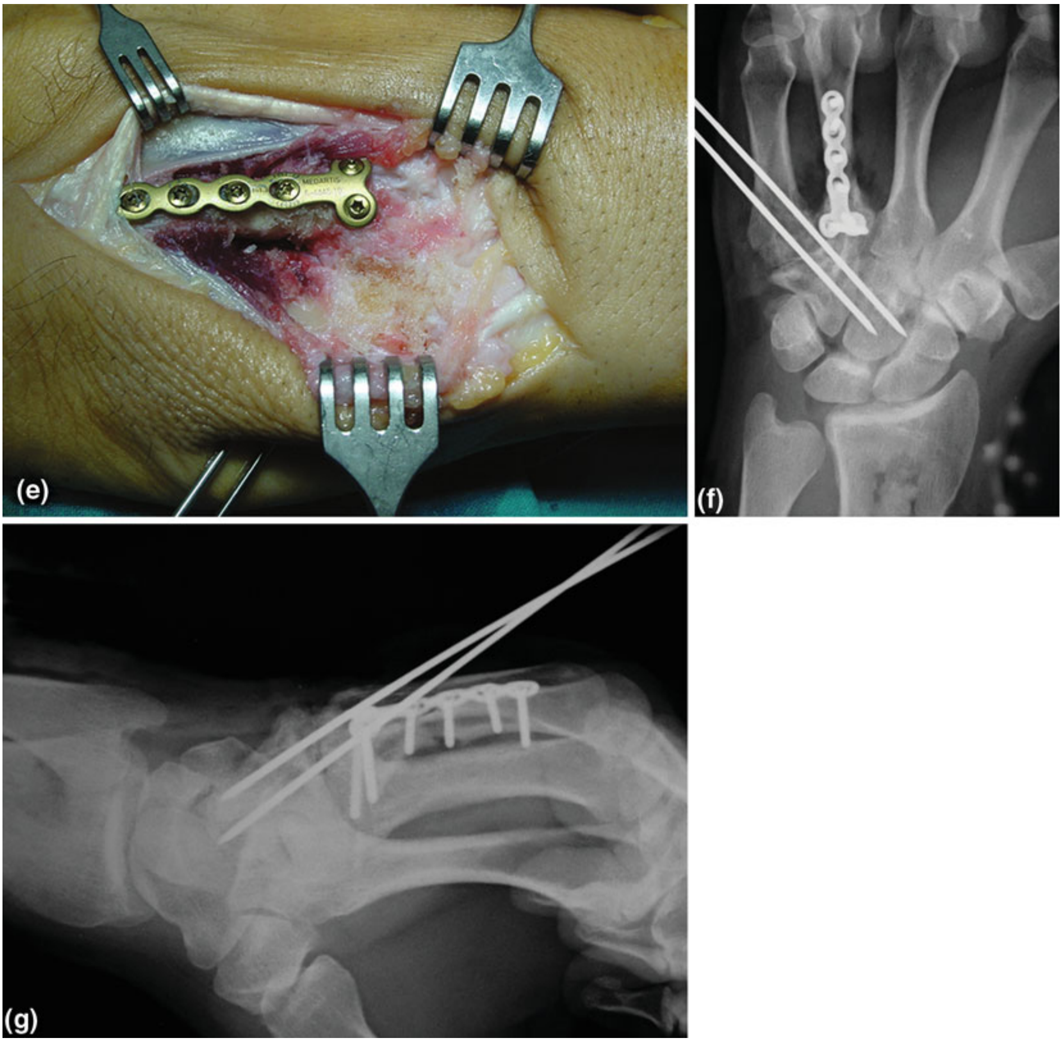


Fig. 9.25 (continued)

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