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Acute bony injuries of hand and wrist

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Abstract

Acute bony injuries to the hand and wrist are very common and are seen on a daily basis in the radiological practice. They do not only occur in high-energy trauma's, but relatively 'simple' falls can lead to many different fractures and dislocations. At the level of the wrist, distal radius fractures are by far the most common. With exception of fractures of the ulnar styloid (often with distal radius fractures), isolated distal ulna fractures are uncommon.

More serious injuries to the wrist include complicated fracture dislocation injuries like perilunate dislocations or lunate dislocation. At carpal level, scaphoid fractures are the most common followed by fractures of the dorsal side of the triquetrum. The scaphoid fractures are the most important ones to recognize because of the potential devastating effect of the complications of missed scaphoid fractures like e.g. pseudarthrosis or avascular necrosis. The metacarpals often fracture. Fractures of the base of the thumb are common, together with the subcapital fracture of the 5th metacarpal. In the fingers we encounter many different types of fractures, often in avulsions reflecting underlying soft tissue pathology (e.g. Mallet finger). Dislocations are common in the fingers predominantly in the PIP joints. From an imaging standpoint conventional radiography is always the initial imaging examination. Complex (intra-articular) fractures, fracture-dislocation injuries and strong clinical suspicion of radiographically occult fractures need to be further evaluated and is predominantly used for decision making regarding treatment. CT is the primary imaging modality of choice for the first two. In the latter, MRI can be preferable, but this depends upon the clinical suspicion and the local situation in your hospital.

Keywords

- Wrist
- Hand
- Fractures
- Dislocation
- Imaging

Radius injuries

Distal radius fractures are the most common fractures in the wrist[1-3]. In the elderly population it is, after hip fracture, the 2nd most common fracture[2]. Although distal radius fractures are encountered at any age there are 2 age peaks in which they are more frequently seen: 10-14 years old adolescents and in adults after 50 years of age[3]. They are usually caused by a fall on an outstretched hand ('FOOSH') with the wrist most of the times in hyperextension. There are many different types of intra- and extra-articular fractures designated by different eponyms like Colles fracture, Barton fracture, Smith fracture, Chauffeur's fracture etc. There is controversy about the use of these eponyms. Most of the eponyms are from physicians who described the fracture for the first time but most of these fractures were described before the discovery of X-rays. Therefore, it is difficult to state whether ithe fracture that bears their name is in fact the fracture that they described clinically[4]. Nevertheless, the eponyms are still widely used in daily clinical practice. It would be better to classify fractures according to a (reproducible) classification system but therein lies a problem. There is no widely accepted classification system for distal radius fractures. There are up till now more than 20 different classification systems described (e.g. Frykman, Melone, AO). There are several reports that assessed intra- and interobserver reliability of the most commonly used classification systems and in general they found low numbers for reproducibility and outcome after treatment[2,5-8]. If there is any need to classify, it would be useful to use the same classification system as the surgeons use, otherwise classifying becomes a goal on its own without any benefits to the patient or surgeon. Therefore, it is preferable to provide an accurate and complete description of the fracture morphology. There are several factors that have to be assessed when describing the morphology of a distal radius fracture (▸**Table 1**)[9-10]. Some of the features are more important than others and there seems to be a better consensus amongst surgeons (compared to which classification system to use) which patients have to be operated upon and which can be treated conservatively. Especially in young patients, it is unclear and inconclusive if surgery will lead to a better outcome compared to conservatively treated patients.

Initial imaging after a fall on the hand/wrist is always standard radiography. PA and lateral X-rays have to be made in 2 orthogonal planes. The value of correctly made plain films cannot be underestimated. They should be made according to strict protocol to eliminate pro-supination in the lower arm to avoid wrong diagnoses, e.g. when the position of the distal ulna

is assessed and called abnormal. (Sub) luxation of the distal ulna is sometimes called on improperly made plain films (especially on the lateral view) which will disappear if repeat films are made with 'true' lateral views in which the diaphysis of the radius and ulna are properly superimposed (FIGURE) (▸**Fig.1**). The latter can only be achieved if a lateral view is made with the shoulder in 0^0 abduction and 90^0 flexion in the elbow with the medial side of the 5th finger flat on the x-ray table. Additional views are somewhat controversial although it is recommended by the ACR appropriateness criteria to add a 3rd view and possibly even a 4th view, the 45^0 semipronated oblique view and the semisupinated oblique view respectively[11].
The initial survey when looking for a fracture is the assessment of the integrity of the cortices of the bones. Subtle fracture lines are sometimes seen in only 1 plane. The trabecular bony structure has to be evaluated, fractures can present themselves as small, usually somewhat linear, lucent or sclerotic configurations within the marrow cavity (FIGURE). With regards to the soft tissues, the pronator fat pad sign, in which the normal sharp outline of the pronator quadratus on the palmar aspect of the wrist is lost, can be indicative of a fracture although this sign has a high specificity but a low sensitivity for distal radius fractures[12].

▸**Table 1.** Important factors to evaluate in distal radius fractures

1. Extra-articular or intra-articular fracture
2. Radial inclination (coronal plane – PA view)
3. Radial height (coronal plane – PA view)
4. Palmar or dorsal angulation of the distal part of the radius (sagittal plane – lateral view)
5. Ulnar variance
6. Is it a 'simple' fracture or is there comminution?
7. Involvement of the sigmoid notch – congruence of the Distal Radio-Ulnar Joint (DRUJ)
8. Presence or absence of ulnar styloid fractures.
9. 9.Intra-articular step-off

Radial inclination is the angle of the distal radial surface compared to a line perpendicular to the diaphysis of the radius, it is measured on an PA view (FIGURE). A normal inclination ranges between 21-25 degrees[10]. The radial height, also measured on PA radiograph, is the distance between 2 parallel lines drawn perpendicular to the long axis of the radius (FIGURE). The 1st line is drawn from the radial styloid, the 2nd at the level of the ulnar aspect or ulnar edge of the lunate fossa. Its range lies between 8-14 mm[10]. The palmar or dorsal angulation is measured on a lateral radiograph by a line between the volar and dorsal lip of the radius perpendicular to the long axis of the radius (FIGURE). The distal radial articular surface almost always displays a palmar angulation of approximately 11 degrees[10]. Ulnar variance can be measured in different ways; the “normal” ulnar variance can basically only be assessed in the non-injured wrist[13]. Assuming that most patients are fairly symmetrical, the ulnar variance of the non-injured wrist can give an idea of the normal ulnar variance before the fracture was sustained.

There seems to be a trend towards more surgical treatment of distal radius fractures although, like mentioned previously, there is no general consensus about the optimal treatment. The age of the patient plays an important role and in general it can be said that the younger the patient the more likely it is that he/she will be operated upon. Extra-articular fractures with acceptable closed reductions will usually be treated conservatively. Intra-articular fractures are more commonly operated upon even after acceptable closed reductions especially in patients under 65 years of age. Severely comminuted or displaced fractures are almost always treated surgically. Operative treatment usually consists of volar plating with locking plates. Closed reduction with percutaneous pinning (CRPP) is usually reserved for fractures in children and it not commonly used in adults. In intra-articular fractures, the size of the gap in the articular surface of the radius is considered to be of importance. It is for this reason (and in severely comminuted and displaced fractures) that more and more patients receive follow-up imaging after X-ray in which Computed Tomography (CT) or alternatively Cone Beam CT is the preferred method of choice. MRI does not play an important role in the evaluation of distal radius injuries unless there is clinical suspicion of accompanying injuries to the soft tissues like the scapho-lunate (SL) ligament or Triangular Fibrocartilage Complex (TFCC). Nevertheless, distal radius fractures are detected sometimes when a patient is referred for MRI for clinical suspicion of occult scaphoid fracture (FIGURE).

Colles fracture

The most common distal radius fracture is the Colles fracture, which was named after the Scottish surgeon who described this fracture in 1814. The eponym is usually used to describe an extra-articular metaphyseal distal radius fracture in which the distal part is tilted dorsally. It can consist of a simple fracture line or it could be comminuted, however, the articular surface is usually not involved although sometimes in a typical Colles-like fracture there can be extension of a fracture line to the articular surface. There is loss of radial inclination and height, dorsal angulation of the distal part and often there is an accompanying fracture of the ulnar styloid (FIGURE). Conventional radiography usually suffices for diagnosis.

Treatment consists usually of 4-6 weeks cast immobilization after successful reduction of the fracture. In younger patients however, especially when there is comminution at the dorsal side with bone loss, operative treatment is more common, because of an expected high likelihood of a loss of reduction in these patients.

Smith fracture

The Smith fracture is named after the Irish surgeon Smith who described this fracture in 1847. It is a similar fracture as the Colles fracture but in Smith fracture the distal part of the radius is tilted in a palmar direction, hence it is sometimes referred to as a reversed Colles fracture. It is less common than Colles fracture. The eponym is predominantly used (as in Colles fracture) to describe an extra-articular fracture. There is loss of radial inclination and height with palmar tilt of the distal part of the radius (FIGURE). The same therapeutic principles apply as for the Colles fractures. Comminution and bone loss in Smith fractures is -however- located on the palmar side.

Barton fracture

Barton fractures are seen in 2 different forms: palmar or dorsal Barton fracture. They are named after the American surgeon Barton who described the fracture in 1838. It is an intra-articular fracture of the distal radius of either the palmar or dorsal rim with associated displacement of the carpus which usually maintains its normal relation to the displaced fragment. They are uncommon but operative treatment is often necessary in these fractures, hence the need for cross-sectional imaging after plain films to establish the degree of dislocation and to assess the articular gap. The width of the articular gap and the step-off in the articular surface are the most important prognostic factors in these fractures. A step-off of 2 mm is generally considered the cut-off point (▸ **Table 1**) There appears to be a good consensus that a larger step-off and gap is an absolute indication for surgery especially in patients under 65 years of age[6]. Depending upon the type and extension of the fracture and the size of the displaced fracture fragment the radial inclination and height could be partially preserved (FIGURE x2).

Chauffeur's fracture

The chauffeur fracture is an oblique intra-articular fracture of the styloid process of the radius. The name chauffeurs' fracture is derived from the period that cars were started with crank-handles. If the car back-fired during the crank the handle was forced backwards into the palm of the hand which gave rise to the typical fracture. It is sometimes referred to as the Hutchinson fracture after the British surgeon Hutchinson who described this fracture in 1866. The loss of radial inclination and height and the amount of angulation of the distal part varies (FIGURE). Treatment can be either conservative or operative depending upon the dislocation of the fracture fragment and the congruity of the radial articular surface in which the same rules apply as mentioned earlier.

Die-punch fracture

A die-punch fracture is an uncommon fracture of the ulnar-sided articular surface of the distal radius ('lunate fossa') with an intact radial styloid process. It arises from an axial loading on the distal radius in which the lunate bone is driven into the distal radius. The radial inclination and height are only disturbed at the level of the depressed fragment of the lunate fossa

(FIGURE). Die-punch fractures are almost always operated upon unless the depression of the lunate fossa is less than 2 mm.

Pediatric fractures

Fracture patterns in children and young adolescents differ from that in adult patients[14,15]. The bones in children are more flexible compared to adults and the weakest part of the bone is usually the physeal plate. There are 4 types of fractures identified in children:

1. Torus or buckling fractures
2. Greenstick fractures
3. Bowing fractures ('Plastic deformation')
4. Epiphysiolysis (Salter-Harris) fractures

In torus or buckle fractures there is, usually (semi) circumferential, buckling of the cortex of most often the distal radius (FIGURE). It differs from greenstick fractures, in which there is a cortical breakthrough of the bone on one side with preserved integrity of the opposite cortex (FIGURE). If the breakthrough of the cortex is bi-cortical it is simply called a fracture. Bowing fractures are diagnosed when there is an abnormal configuration or alignment of a bone without visible cortical disruption or breakthrough. It is, however, often accompanied by a fracture of the accompanying bone (e.g. in the lower arm bowing of the radius is usually accompanied by an ulna fracture) (FIGURE). Fractures involving the epiphysis and physis are called and classified as Salter-Harris fractures; they are only seen in individuals in which the growth plate is still open. They are quite common in the distal radius. They are classified according to severity in 5 types. They are at risk of premature closure of the physeal plate especially in the more severe types (FIGURE). The most common are Salter-Harris type 2 fractures in which the epiphysis is displaced together with a small part of the fractured metaphysis. Children are usually treated conservatively. More dislocation and angulation can be permitted in the growing individual compared to adults due to the remodeling capacity of growing bones[14]. Only in cases with severe dislocation and unsatisfactory results after closed reduction, operative treatment is necessary. Usually, to be as non-invasive as possible, this is done by CRPP. Operative treatment is usually also applied to very distal antebrachial complete fractures because these can be very unstable.

Ulna injuries

Isolated fractures of the distal ulna at the level of the wrist are rare. More proximal, in the lower arm, ulnar fractures are not uncommon. Most common fractures or injuries to the ulna in the lower arm are:

1. Isolated ulnar diaphyseal fracture ('nightstick fracture').
2. A fracture of the ulna and radius together as antebrachial fracture (often pediatric).
3. The Monteggia injury in which there is a fracture of the distal ulna diaphysis together with a dislocation in the proximal radio-ulnar joint.
4. The Galeazzi injury in which there is a fracture of the mid- to lower diaphysis of the distal radius combined with a dislocation of the distal ulnar head from the DRUJ (FIGURE).
5. Ulnar styloid fractures usually combined with distal radius fractures.

A Galeazzi injury is not frequently seen; posttraumatic instability of the DRUJ with (sub)luxation is most common due to injuries of the Triangular Fibrocartilage Complex (TFCC) or to the styloid process of the ulna to which the TFCC attaches. If, in a posttraumatic patient, there is suspicion of a (sub)luxation of the DRUJ, one always however needs to make sure that the whole lower arm is imaged with X-ray to exclude an injury to the more proximal radius. Fractures of the most distal part of the ulna are almost always to the ulnar styloid. They are very commonly seen in patients with distal radius fractures and in cases of (greater arc) perilunate fracture dislocations (see combined injuries). Surgical repair is almost never indicated because even non-union of these fractures do not seem to affect clinical outcome[16].

Carpal injuries

Carpal fractures are seen in isolation or in complex fracture-dislocation injuries. Isolated carpal fractures are most common in the proximal carpal row, most often in the scaphoid and secondly to the triquetrum[17,18]. Isolated lunate and pisiform fractures are not often seen. In the distal carpal row fractures of the trapezium are sometimes seen accompanying scaphoid injuries or in isolation. Trapezoid, capitate and hamate fractures in isolation are rare. Initial imaging in suspicion of carpal fractures is with conventional imaging but the individual carpal bones are often difficult to assess because of their complex shape and because of their position in between the other carpals. After X-ray, (CB)CT is the primary imaging modality in case of strong suspicion of a fracture but in patients with persistent wrist pain with equivocal findings at clinical examination, MRI is also a very valuable tool to detect occult (micro) fractures or bone bruise[19]. It has already been demonstrated in many studies that there is a substantially number of occult fractures detected on MRI in patients who are previously diagnosed as having a 'wrist sprain' or 'wrist contusion'[21].

Scaphoid

Scaphoid fractures are quite common after a FOOSH. It is the most common fracture of the carpal bones, up to 70 % of cases[18]. Standard 2-view wrist radiographs are usually not sufficient to detect scaphoid fractures. 2 additional views have to be made to increase the sensitivity of plain films which is notwithstanding low[23] (FIGURE x2). The clinical presentation has to be the decisive factor for treatment in case of negative X-rays. After a period of 7-10 days the patient has to be re-examined clinically. In case of persistent pain in the region of the scaphoid, additional imaging has to be performed. Repeated plain films are, in our opinion, not useful. It is not to be expected that there will be sufficient bone resorption in this limited time to demonstrate the fracture line. If the fracture line is seen after this period on plain films it is almost certainly due to a minor difference in rotation when making the plain films, in which the fracture line is in the same plane as the x-ray beam and therefore demonstrated. In our opinion, MRI or CT has to be made to confirm the diagnosis of scaphoid fracture or possible other fractures. MRI is in this respect superior over CT. MRI can also rule out the presence of a scaphoid fractures contrary to CT which can only rule in fractures[24]. Whilst initially there were strong objections against cross-sectional imaging as a 2nd step instead of repeating plain films for reasons of increase in costs, it has been sufficiently demonstrated that cross-sectional imaging is cost effective[25-27]. It has also been demonstrated that many patients who are diagnosed as having a 'wrist sprain', actually do have a large number of occult bone and soft tissue injuries)[21]. That scaphoid fractures are not seldomly missed is also demonstrated by the fact that quite often the complications (e.g. pseudarthrosis, avascular necrosis) are seen on plain films of patients who weeks to months after a trauma keep complaining of wrist pain (FIGURE). The results of these complications can be devastating in young patients. Therefore, we recommend a more liberal use of (CB)CT and MRI to detect fractures or other lesions in the wrist in post-traumatic patients with persistent pain.

Triquetrum

The triquetrum is the 2nd most common fracture seen in the proximal carpal row, up to 18 %[18]. It almost always involves an avulsion injury at the dorsal side of the bone. Mechanisms of injury could be an avulsion (of the ligaments), impaction (by the ulnar styloid) or shearing (by the proximal pole of the hamate). A fracture of the triquetrum body is much less common; they are most often the result of high energy trauma or complex perilunate fracture-dislocation injuries. A 3rd fracture of the triquetrum is the palmar cortical fracture, but this is very rare[17,19]. The dorsal fractures are often and best seen on a lateral radiograph of the wrist (FIGURE). Body fractures and palmar fractures can be difficult to detect on either PA or lateral plain films because of superposition of the pisiform (PA) or other carpal bones (lateral). Additional oblique views could be helpful in these cases, but the sensitivity overall is relatively low. In case of suspicion of a fracture of the (body) of the triquetrum with negative X-rays a CT has to be considered.

Pisiform and lunate

Both isolated lunate and pisiform fractures are rare[17-20]. Lunate fractures can occur in trauma situations where there is axial compression of the capitate against the lunate or in complex perilunate dislocation injuries. They can also occur in late stage Kiënbock's disease in which the lunate can collapse.

Pisiform fractures occur due to a direct blow against the palmar ulnar aspect of the wrist (e.g. like in a hyperextension injury). Although these fractures are sometimes seen on PA plain films it can be difficult to detect them. Specific views (piso-triquetral joint view or carpal tunnel view) can be made to increase fracture conspicuity. (CB)CT is -hwover- more sensitive for detection (FIGURE).

Trapezium and trapezoid

Isolated fractures of the trapezium are rare[17-20]. The trapezium can be involved in patients who sustain an injury to an abducted thumb often then in combination with a fracture to the thumb. They are also sometimes seen in patients who are suspected of scaphoid fractures or in patients with distal radius fractures. Isolated fractures of the trapezoid are exceedingly rare[18]. The trapezoid is so well protected within the wrist that fractures almost never occur in isolation although they could be involved in severe fracture-dislocation injuries. The position of the trapezium compared to the trapezoid makes it easier to detect a fracture of the former compared to the latter. Special views that are used for the thumb can also be used to evaluate the trapezium (e.g. Bett's view). However, in case of suspicion of a fracture of either (especially with negative X-rays), CT is the imaging modality of choice. For the trapezium it is recommended performing a CT even if the fracture is obvious at radiography to unravel the fracture pattern more in detail. Figure?

Capitate

Isolated capitate fractures are uncommon, accounting for approximately 1-2 % of all carpal fractures[17-20] (FIGURE); they usually occur in greater arc perilunate dislocation injuries (see further). The head of the capitate is sometimes fractured together with the scaphoid in which there is no apparent dislocation of the carpus; it is however believed to be a subtype of perilunate dislocation injury in which the alignment of the carpal bones is restored during the end-stage of the trauma so that it is not obvious on imaging during presentation. This is the so-called 'scapho-capitate' fracture syndrome (FIGURE). In these cases, it can occur that the fragmented head of the capitate has rotated 180 degrees resulting in alignment between the fragment and the rest of the body of the capitate is lost. If there is any suspicion on plain films that i the capitate is involved, subsequent imaging with (CB)CT is mandatory. The distal part of the capitate can be involved in carpo-metacarpal fracture-dislocation injuries but this is uncommon.

Hamate

The hamate bone is involved in two distinct fracture patterns: isolated hook fractures or fractures of the body or distal portion in carpometacarpal-fracture dislocations of the 4th and/ or 5th metacarpal[17-20]. Hook fractures are typically seen during sports activities in which there is a direct blow of a club (golf), racquet (tennis of squash) or bat (cricket) against the hook of the hamate. It is often occult on plain films and in cases of strong clinical suspicion (CB)CT is warranted (FIGURE). Fractures of the body of the hamate are more common. Fractures of the base of the 4th and 5th metacarpal are not uncommon and because of their articulation with the hamate and because of the increased mobility at this level (compared to the 2nd or 3rd carpometacarpal joints) rotational forces combined with axial forces are responsible for the injury. Very careful evaluation of the carpometacarpal joints at this level in case of fractures of the base of the 4th and 5th metacarpal is necessary, and dislocation is not seldomly missed. In case of any doubt a CT has to be made in which the sagittal reformats are the most helpful (FIGURE).

Combined injuries

The stability of the wrist is derived from the osseous geometry of the distal radius and ulna together with the intricate shape of the different carpal bones together with a large number of soft tissues of which the intrinsic and extrinsic ligaments are the most important ones. Isolated dislocation of carpal bones is therefore exceedingly rare. Usually carpal dislocations are either accompanied by a fracture or fractures or several carpal bones dislocate together. An important concept for understanding the combined bony-ligamentous injuries is that of the greater and lesser arc[28,29]. These are specific vulnerable zones around the wrist-carpus in which most of the severe combined bony-ligamentous injuries occur. The greater arc describes a virtual line around the lunate where fractures together with ligament injuries occur (radius, ulna, scaphoid, trapezium, capitate, hamate and triquetrum). The lesser arc is a similar line around the lunate bone but in these injuries only ligament injuries occur between the lunate and the surrounding carpal bones without fractures. Combined (ligamentous and bony) injuries to the wrist and carpus are usually greater arc injuries or perilunate-fracture dislocation injuries. In lesser arc injuries there is a perilunate dislocation without fracture (rare) or the lunate can dislocate in isolation with a normal alignment of the other carpal bones, but this is even rarer (FIGURE). The nomenclature is not always clear in the literature. Lunate dislocations are sometimes also referred to as perilunate dislocation. The position of the capitate is in our opinion leading. If there is a normal longitudinal alignment of the capitate towards the distal radius with abnormal position of the lunate, we refer to the injury as a lunate dislocation. If there is an abnormal alignment of the capitate, we refer to the injury as perilunate dislocation injury. The dislocation of the carpus in perilunate dislocations is almost always dorsal, palmar dislocation is very rare. In cases of lunate dislocation, the lunate is displaced palmar towards the carpal tunnel. The injuries in greater arc injuries are named after the involved fractured bones e.g. in case of a dorsal perilunate dislocation with a fracture of the scaphoid it is called trans-scaphoid dorsal perilunate dislocation (FIGURE). These complex injuries always need surgery and preoperative cross-sectional imaging is mandatory .

Detection of these injuries is primarily done on conventional radiographs. A relatively easy method to evaluate the position of the carpal bones and their relation to the distal radius and ulna and towards each other are Gilula's lines[30,31]. These are 3 virtual parallel concave lines that can be drawn along the bones in the wrist and carpus. The 1st line is drawn along the proximal surface of the proximal carpal row. The 2nd line is drawn along the distal surface of the proximal carpal row and the 3rd line is drawn along the proximal surface of the distal carpal row (FIGURE). The lines should be parallel and uninterrupted. Any disturbance in the normal configuration of these lines can be an indication of malposition of one or more of the carpal bones. If, at conventional imaging there is suspicion of a fracture or malposition , a CT should be considered as additional imaging tool for further evaluation of the wrist and to find an explanation for the abnormal radiograph if this is not directly apparent from the radiograph itself or if there is any doubt about malposition of any bone.

Metacarpal injuries

Metacarpal fractures are common in daily clinical practice[32]. The base of the 1st metacarpal and the subcapital fracture of the distal 5th metacarpal are the most common[33,34].

The base of the 1st metacarpal is injured either due to the direct fall on the hand or due to an axial trauma to the thumb with the metacarpal in a mild flexed position. Fractures of the base of the thumb can be categorized in 4 types[35]:

1. Extra-articular
2. Intra-articular, Bennett type
3. Intra-articular, Rolando type
4. Intra-articular, comminuted

Extra-articular fractures can often be managed conservatively with immobilization if the position of the thumb after reduction (or already initially) is in a satisfying position. If the angulation in the fracture is severe (usually an angulation of more than 30^0), operative treatment is often applied usually pinning with K-wires or mini-plates (FIGURE).

Intra-articular fractures are in general unstable due to the action of different tendons (adductor pollicis, abductor pollicis longus, extensor pollicis longus) and ligaments to the proximal fragment and to the distal part of the metacarpal[36].
A Bennett fracture, described by Bennett in 1882, is an intra-articular two-part fracture dislocation in which the distal 1st metacarpal is subluxated dorsally, radially, and proximally by the pull of the abductor pollicis longus. The volar oblique ligament and the dorsal ligament complex are important stabilizers of the thumb base. In Bennett fractures, the ligaments remain attached to the undisplaced volar fragment[36] (FIGURE Bennet # MDN 9645179).

The less common Rolando fracture, described by Rolando in 1910, is a 3-part intra-articular fracture dislocation in which there is a Y or T shaped fracture pattern. The diaphysis is separated from the epiphysis by a transverse fracture whilst the epiphysis is separated into palmar and dorsal or radial and ulnar fragments due to the vertical intra-articular fracture (FIGURE #MDN 0578547/9122473).

Although a reduction of a Bennett fracture could be fairly easy, it is difficult to maintain a post-reduction anatomical position. Therefore, these fractures are almost always treated operatively with K-wire pinning or less common screw osteosynthesis or mini-plates. This applies even more so to Rolando fractures in which the individual fragments also undergo their own dislocation leading to an incongruent joint surface which is associated with an unfavorable outcome (i.e. osteoarthritis). These fractures are therefore also operated upon as are comminuted fractures. The treatment goals are restoration of the articular congruity, maintaining of the metacarpal length and to avid narrowing of the 1st webspace[35,36].

Imaging of thumb base injuries is initially with conventional radiographs in which 3 views are recommended: AP, lateral and an oblique view for better visualization of the trapezometacarpal joint. If there is any doubt about intra-articular involvement CT is recommended. Bennett fractures usually do not require CT because the size of the ulnar fragment can usually be assessed on plain films but for Rolando and comminuted fractures CT for pre-operative planning is useful for the assessment of the size and position of the different fragments.

At the level of the head of the 1st metacarpal the most common lesion that we encounter is to the Ulnar Collateral Ligament (UCL). Although this is a predominantly soft tissue injury they can be accompanied by small bony avulsions. These injuries are common in sports ('skiers thumb') and are caused by forceful abduction of the thumb. If, at the level of the 1st metacarpal head, we encounter a small avulsion at the ulnar side we have to suspect an injury of the UCL. Depending upon the clinical situation, US would be the next step in imaging. This is predominantly indicated to rule out a Stener lesion, in which there is interposition of the aponeurosis of the adductor polices in between the distal and proximal part of the UCL preventing it from healing. These lesions are usually treated surgically (FIGURE).

The subcapital fracture of the 5th metacarpal is almost always the result of a blow against a hard object with a clenched fist, hence the term boxer's fracture which- however- rarely occurs in professional boxers because of their proper training and punching technique in which the 2nd metacarpal is more stressed and more at risk than the 5th. of the term fighter's fracture is preferred because it is most usually seen in people who are not trained to use their fists in fighting[32]. These fractures are usually stable, more stable than proximal diaphyseal fractures. Excessive volar angulation of the head of the metacarpal is the major concern in these fractures. Treatment of these subcapital fractures is mostly conservative. The more proximal the fracture, the more instability, the greater is the likelihood that the fracture needs surgical treatment[32,34] (FIGURE MDN 7457758/0155613).

Fractures of the other metacarpals are most commonly seen due to a direct trauma against the hand. The fracture type can reflect the trauma mechanism. 'Simple' horizontal fractures through the diaphysis are the result of a direct trauma whereas in oblique or spiral fractures torsional forces were also applied to the bones. This is also true for fractures of the base of the 4th and 5th metacarpal in which there are usually also significant rotational forces involved. Metacarpal diaphyseal fractures are usually stable and can be treated conservatively. Horizontal fractures are more unstable than oblique or spiral fractures. In the latter however, there are more rotational deformities so close evaluation of the finger distal to the fracture is needed. Excessive palmar angulation of the distal part (because of traction of the interosseous muscles) and the shortening and/or rotation in the metacarpals in oblique fractures are the most important factors that have to be taken into consideration when deciding conservative or operative treatment[32,34].

Fractures of the base of the 4th and or 5th metacarpal are not uncommon. Careful evaluation of the plain films is mandatory to evaluate the carpometacarpal joints; if there is any doubt about carpometacarpal dislocation or involvement of the hamate or capitate bone, (CB)CT is recommended (see section on carpal injuries). There is an intra-articular fracture of the base of the 5th metacarpal which resembles the Bennett fracture of the thumb and is sometimes referred to as reversed Bennett fracture (or baby Bennett)[32]. Part of the base of the 5th metacarpal on the radial side maintains its normal articulation with the hamate whilst the more distal part of the metacarpal is prone to subluxation proximally and dorsally due to traction of the extensor carpi ulnaris tendon making it an inherently unstable fracture.

Dislocations at metacarpophalangeal level

Dislocations at metacarpophalangeal level are not common[37]. The MCP joints are relatively protected against these injuries due to their position in the hand and they are more stable than the other finger joints. They derive their stability from the flexor tendons, the lumbrical muscles, a volar plate, collateral ligaments and deep transverse intermetacarpal ligaments. There are only case reports about these injuries and although they are described in any finger, the index finger seems to be most often involved, followed by the thumb (FIGURE).

Finger injuries

The most common fractures in the hand after distal radius fractures are phalangeal fractures, although there is a slight difference in distribution amongst men and woman and between different age groups, the former being more common in females and the latter slightly more common in men[33,38]. Etiology is slightly different among age. Children are more at risk possibly because they are in the exploratory phase of their life making the fingers more vulnerable to trauma[14]. In adolescents finger injuries often occur during sports activities[14]. Sports participation and falls account for most injuries in adults[39]. When assessing finger fractures several features are of importance. Clinical assessment is predominantly focused on deformities in the coronal and sagittal plane. Another very important clinical assessment is the absence or presence of significant rotation in the finger between proximal and distal which can occur predominantly in oblique or spiral fractures[14,39]. Radiologically distinction has to be made between extra- and intra-articular fractures. In the pediatric population the most important differentiation is whether or not the growth plate is involved. In addition to fractures, joint dislocations are commonly seen in the fingers in the proximal interphalangeal (PIP) and less common in the distal interphalangeal (DIP) joints. These can occur with and without fractures.

Conventional radiographs usually suffices for evaluation of finger injuries. CT is rarely performed and only reserved for some selected cases of intra-articular fractures in which surgery is contemplated depending upon the position and size of the bony fragments and the amount of disturbance of the articular surface. MRI does not have a significant role in the acute setting for bone evaluation.

Conventional radiographs should ideally be made in 3 planes: AP, lateral and oblique[40]. Evaluation of fractures is usually straigthforward although it can be difficult sometimes to assess the degree of angulation in fractures at the base of the proximal phalanges due to superposition of the other bones. Intra-articular fractures can involve the base of the proximal, middle and distal phalanges involving respectively the MCP, PIP and DIP joints. Another type of intra-articular fractures are fractures of the heads/condyles of the proximal and middle phalanx, involving respectively the PIP and DIP joints. Diaphyseal fractures are seen in all 3 phalanges but more common in the proximal phalanx. In the distal phalanx we encounter tuft fractures.

Proximal phalanx and PIP joint

Angulation in base and mid proximal phalanx fractures is usually apex palmar because of the different contributions of the soft tissues to the different fragments. The lumbricals and interossei attach to the proximal part of the phalanx, will flex this part, and the central slip attachment of the extensors pulls the distal part in extension[32] (FIGURE). Extra-articular subcapital or neck fractures are very rare in adults but not uncommon in children. Intra-articular condyl fractures of the proximal phalanx can be classified in 3 types: type 1, stable fractures without displacement, type 2, unicondylar unstable and type 3, bicondylar unstable. Treatment of proximal phalanx fractures is usually conservative. Operative treatment is reserved for some cases in which there is severe comminution, instability, unsatisfactory position after reduction, open or complicated fractures or fractures which are accompanied by severe soft tissue injuries. Operative treatment can be done with CRPP, mini plates or mini screws.

Dislocations in the PIP joint are almost always with displacement of the middle phalanx dorsally (FIGURE). Volar dislocations are rare. Both dislocations can occur with and without fractures to respectively the volar and dorsal lip of the base of the midphalanx. Special attention has to be given to the soft tissues at the palmar side of the PIP joint e.g. the volar plate. Although we can safely assume that the volar plate will be ruptured in these cases, fractures are not always seen. Suspicion of volar plate lesions are however very commonly seen on radiographs without a dislocated PIP joint and present themselves as small avulsion fractures at the level of the palmar base of the midphalanx (FIGURE). Volar plate avulsions can also be detected by ultrasound.

Middle phalanx and DIP joint

The middle phalanges are the least common involved in fractures[40]. Like in proximal phalanges fracture can involve the base, shaft and condyles. In fractures of the middle phalanx the deformity and dislocation patterns are less predictable due to counterforces between the central slip of the extensor and the 2 terminal slips of the flexor digitorum superficialis (FDS)[32]. A special rare type of fracture-dislocation of the base is the so-called pilon fracture-dislocation in which an axial force splits the base of the midphalanx in which the fragments are displaced to the palmar and dorsal side and in which there is shortening of the midphalanx. Although these injuries are generally operated upon because of the unstable nature of the injury, in general there is no good consensus about which middle phalanx base fractures need to be operated upon[41,42]. Dislocations of the DIP joint are not very commonly seen. Avulsions at this level are frequently seen however (see section distal phalanx).

Distal phalanx

In distal phalanx fractures there are no deformity causing forces and usually there is no significant deformation or dislocation besides that due to the trauma itself[32]. Fractures can involve the base, the diaphysis or the tuft. It usually involves crush injuries or axial loading traumata. A special type of injury is the so-called Seymour fracture in children[14]. It involves the physeal plate and is therefore a Salter-Harris fracture, most often a SH-type 2. It is the result of forced hyperflexion of the distal phalanx. It is a complicated, open fracture with injury to the nailbed on the dorsal side and dorsal apex angulation in the fracture. There is a certain number of avulsions that are seen from the distal phalanx at the level of the DIP joint. The most common is the avulsion of the dorsal base of the distal phalanx in the so-called Mallet finger[40,43]. A Mallet finger results from a forced hyperflexion of the DIP joint leading to an injury of the insertion of the extensor tendon (FIGURE). They can be pure tendinous or with a bony avulsion which is best seen on a lateral radiograph. Treatment is conservative with a

Mallet splint which prevents flexion in the DIP joint. Another avulsion at the palmar base of the distal phalanx is seen in the Jersey finger[43]. The trauma mechanism is hyperextension of the DIP joint, resulting in an avulsed fragment at the inserion of the flexor digitorum profundus. In contrast to the Mallet finger these lesions are very often treated operatively. Fingertip injuries are common especially to the soft tissues. In more severe cases radiographs are made to exclude bony injuries which is most common to the tuft. Fractures can be transverse, longitudinal, comminuted or there can be partial amputation (FIGURE).

Conclusions

Acute bony lesions in the wrist and hand are extremely common in daily clinical practice. In the distal upper extremity, distal radius fractures are the most ubiquitous often with concomitant fracture of the ulnar styloid process. Isolated distal ulna injuries are rare. At carpal level, scaphoid fracture is the most common followed by the triquetrum as 2nd most common fracture. Isolated fractures of the other carpal bones are uncommon but can be seen in complex fracture-dislocation injuries. In the metacarpals, the thumb and 5th finger are most often fractured. In the thumb this is usually an intra-articular fracture of the base whilst in the 5th finger it is usually a subcapital fracture. In the fingers, a multitude of different fractures are seen in all phalanges. Additionally, dislocations are common in the fingers, most often of the PIP joint. MCP and DIP dislocations are relatively rare. Small periarticular avulsions are common in the fingers and are a reflection of underlying soft tissue pathology e.g. UCL injury in the thumb and avulsion of the extensor in a Mallet finger.

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