Chapter 26

Carpal Bone Fractures and Dislocations

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(Editor’s Note: This chapter will alert the surgeon in district hospitals to common wrist pathology. It is recognized that many will not have the expertise to handle all of these problems as they require good x-rays, knowledge of anatomy, sometimes a C-arm, electric pin driver, plenty of K-wires, and often loupe magnification.)

Carpal Bone Fractures

The wrist joint is the most complex joint of the body. It is formed by the distal radius and ulna, the proximal surfaces of the 5 metacarpal bones, the 8 carpal bones articulating with these 7 bones and each other, the wrist and finger tendons traversing and being an integral part of the joint anatomy and function, numerous ligaments, and other soft tissue structures. The diverse components of the wrist have an exact relationship to each and in its complexity results in tremendous mobility.

Wrist - Palmer View

1-1st metacarpal base (thumb)
2-2nd metacarpal base
3-3rd metacarpal base
4-4th metacarpal base
5- 5th metacarpal base
6-Trapezium
7-Trapezoid
8-Capitate
9-Hamate
10-Scaphoid
11-Lunate
12-Pisiform
13-Triquetrum
14-Radial styloid
15-Radial shaft
16-Ulnar styloid
17-Ulnar shaft

Fig 1
Palmar view of wrist—note the position of ulnar styloid on ulnar side of ulna
(From www.ORIF.com, used by permission)
Wrist injuries are common and unfortunately often missed with resultant degenerative arthritis and chronic pain and limitation of motion. Prompt recognition and proper treatment of the acute wrist injury is paramount in preventing these disabling consequences.

The most common injuries are sprains, scaphoid fractures and scapholunate ligament injuries and this chapter will primarily on these.

![Fig 2](Dorsal view of wrist—note styloid process in center of distal ulna on dorsal view (From www.ORIF.com, used by permission)](image)

### Scaphoid fractures

Scaphoid fractures are the most common carpal fractures and constitute approximately 60-70% of all carpal injuries. The fracture is more common in the young adult male and rare in children because the distal radius physis usually fails first. A similar injury in older people often results in a distal radius fracture as a Colles’ fracture.

![Fig 3](Adult scaphoid fracture (From www.ORIF.com, used by permission))
**Mechanism of injury**

The scaphoid crosses both carpal rows and this makes it more susceptible to injury than other carpal bones (Fig 1 and 2). The injury occurs when the hyper-extended wrist is subjected to an axial load. (Fig 3)

![Fig 4](image)

*Mechanism of fracture of the Scaphoid according to Weber and Chao:*

Force applied to the radial half of the palm (arrow A) with the wrist in 95 to 100 degrees of dorsiflexion, produces bending loads to the unprotected distal half of the scaphoid. The proximal half is protected between the radius and the radiopalmar ligaments (RL= radiolunate, RCS= radioscapohocapitate)


**Blood Supply to the Scaphoid Bone**

The scaphoid bone is shaped like a twisted peanut and 80% of its surface is covered in articular cartilage. The majority of the scaphoid blood supply, up to 80%, is through dorsal ridge vessels that enter the bone distal to the waist, accounting for its retrograde blood flow (Fig 5). This leads to a high incidence of avascular necrosis, especially in proximal pole fractures.

![Fig 5](image)

*Schematic drawing of the arterial supply of the lateral aspect of the wrist: R, Radial artery; Note: 4 is branch to scaphoid tubercle and trapezium

(From Gelberman RH J Hand Surg 1983; 8:367. Used by permission)
Fig 6
Arterial supply of the palmar aspect of the wrist from the radial and ulnar arteries
(From Gelberman RH J Hand Surg 1983; 8:367. Used by permission)

Scaphoid Fracture Classification:

Anatomical
♦ Middle third; most fractures (70-80%) occur in the central third or "waist" of the scaphoid because of the force transmitted by the radio-scaphocapitate ligament in this region  Fig 5
♦ Proximal third: approximately 20% involve the proximal pole and
♦ Distal third: 10% the distal pole

Fig 7
Scaphoid—middle Third Fracture
The clinical reason for differentiating between the types is the variation in healing ability.

Recently more emphasis has been placed on the stability of the fractures. Displacement implies instability and fracture stability is necessary for union but also for preservation of normal wrist mechanics. Cooney et al define a displaced fracture as having

- more than 1 mm offset, or
- more than 15° of lunocapitate angulation or
- more than 60 degree of scapholunate angulation.

**Diagnosis**

The diagnosis of acute scaphoid fractures still continues to be missed. A scaphoid fracture is likely if the clinical examination demonstrates

- snuffbox tenderness
- axial load pain
- palmar tubercle tenderness
- pain with resisted pronation.

**X-ray Examination**

Clinical examination can often suggest a scaphoid fracture with normal radiograph appearance.

In addition to the standard postero-anterior, pronated oblique and lateral views of the wrist, the radial and ulnar deviation studies (scaphoid views) especially with ulnar deviation while making a fist, will exert a distraction force on the scaphoid fragments. The PA ulnar-deviated view is a simple x-ray that is very helpful by extending the scaphoid and bringing it more completely into view. (If the examination findings suggest a scaphoid fracture but radiographs are normal, magnetic resonance imaging has 100% sensitivity – but this is only available in a few centers in Africa). Ultrasonography and computed tomography are not as useful in the diagnosis of acute scaphoid fractures.
Precise radiographs are also essential to adequately assess fracture and carpal stability. (See section on Carpal Ligament injuries below) Seemingly stable fractures have been known to displace as late as six weeks after the injury.

When there is a high degree of suspicion for a scaphoid fracture but x-rays are normal, one should splint the wrist and repeat the x-ray in 2 weeks.

**Treatment:**

**Non-operative treatment**

Most non-displaced scaphoid fractures will heal with 12-16 weeks of thumb spica cast immobilization. Proximal pole fractures may take longer to heal, sometimes requiring up to 6 months of immobilization.

Non-displaced fractures have a union rate of more than 95% when diagnosed promptly and properly immobilized.

The **position of immobilization** of these fractures should be the reverse of the mechanism of production; a short arm thumb spica cast with the wrist in slight palmar flexion and radial deviation. This position approximates the fracture fragments and the radial deviation may prevent or correct the dorsal tilt of the lunate associated with displaced or unstable fractures. The thumb is placed in palmar abduction with the distal joint left free. Some studies suggest a long arm cast for 6 weeks and an additional short arm cast for 6 weeks. These studies suggest a greater incidence of non-union when short arm casts are used. There is no consensus on the best position of the wrist.

**Criteria for bony union** are demonstration of trabeculation across the fracture site and obliteration of the fracture line on all radiographic views.

The patient is seen every 3 weeks, the X-rays repeated without the spica. The thumb spica reapplied and only permanently removed when radiographic healing is certain.

**Operative treatment**

Accurate diagnosis of even the slightest displacement is important, for healing depends on precise reduction and immobilization.

Eddeland reported a non-union rate of almost 92% when fractures with displacement of 1mm or more were treated conservatively.

(a) **Displaced fractures.**

**Indications for operative treatment** of acute scaphoid waist fractures include;

- more than 1 mm of displacement
- comminution—likely not an indication in district hospitals
- open fractures
- associated carpal instability
Displaced fractures require accurate reduction, usually open in our hospitals, and secure internal fixation using K-wires.

**Technique:**
1. Waist fractures in which operative fixation is indicated is best approached volarly to better preserve the critical dorsal blood supply. The incision is along the FCR tendon. The tendon is retracted ulnarly (medially) and radial artery to the radial side. The incision is then carried down to the radiocarpal joint and then up to the trapezium. The scaphotrapezial joint is opened. Dorsiflexion of the wrist allows a clear view of this joint so that K-wires can be passed from distal to proximal through the scaphoid.
2. Direct vision of both joints will enable one to pass the K-wires accurately and not leave the end of the K-wire in the radiocarpal joint. Wide exposure is necessary since many will not have a C-arm.
3. The fracture is accurately reduced by pushing the two fragments together - periosteal elevators can be very useful - and whilst being held together, transfixed with K-wires; usually two wires of 0.045 or 0.035 thicknesses. Leave the ends of the K-wires subcutaneous so they can be pulled out when the fracture is completely healed.
4. Full radial deviation of the wrist will correct the lunate dorsiflexion if present and this bone can be fixed to the scaphoid and/or a capitate with additional K-wires.
5. Dissection proximal to the radiocarpal joint will expose the distal radius so that one can harvest a bone graft if necessary.
6. Displaced scaphoid fractures with significant scapholunate instability are best approached dorsally for accurate reduction and fixation of the lunate instability and the scaphoid fracture.
7. Apply a thumb spica as described above for the non-operative management of undisplaced scaphoid fractured.
8. See every 3 weeks with repeat X-rays on every visit
9. Cast and pins are removed with complete radiological healing evident: trabeculation across the fracture site and obliteration of the fracture line on all radiographic views.

The above technique can be effectively done without a C-arm. But even if a C-arm is available this described technique is probably still preferable as insertion of percutaneous K-wires under the C-arm is extremely difficult to use if the surgeon is not experienced with it.

*(Editor’s Note: For those inexperienced in wrist surgery, a dorsal approach may be easiest.)*

The use of a compression screw is indicated (Fig 6) if available and if a C-arm is available but it is technically more difficult to insert and if incorrectly placed can cause considerable damage.
Bone grafting

This may be indicated if there is significant comminution. The distal radius is a nearby source for bone. (See above.)

(b) Delayed and nonunion.

Consideration to bone-grafting should be given if signs of union are lacking at about eight weeks after injury with adequate treatment. Some authors advise a trial period out of plaster or the radiological demonstration of fracture instability before advising surgery as many delayed or non-unions are essentially symptom-free.

Indications for Surgery

Surgical treatment is indicated for all painful delayed and painful non-unions regardless of the presence of degenerative, avascular or cystic changes.

The choice of the procedure will depend on the type of the fracture, the patient's age and the presence of carpal degenerative changes.

Bone grafting is the basic treatment for all non-unions except those with carpal arthritis, avascular necrosis and carpal collapse.

A popular technique is the Matti-Russe bone graft technique; removal of the centers of the two fragments (hollowing out of the open ends) and filling of the created cavity with a single piece of cancellous bone. See pictures in orthopaedic or hand texts. This is the best technique for most of our hospitals.

Cooley found an 85% union with bone grafting whether by the dorsal or volar approach. Avascular necrosis improved in all cases where union occurred. There was a greater incidence of failure after bone
grafting in displaced fractures (35%) than in undisplaced fractures (90%). Post-fracture arthritis was also more common in the displaced group. Therefore we feel that internal fixation should be considered early when the fracture is displaced or unstable.

If there is any avascular necrosis, arthritis, or collapse, a proximal row carpectomy or total wrist fusion is recommended. These operations are predictable, do not require much technology or advanced rehab, and give very functional results.

The **SNAC (scaphoid nonunion advanced collapse)** wrist refers to the progressive arthrosis seen in scaphoid non-unions.

Surgical treatment can help prevent the development of a SNAC wrist if treatment is instituted before the onset of arthrosis. Surgical fixation with pins or screws, with or without bone graft, is typically preferred. When there is an associated humpback deformity of the scaphoid nonunion, a volar intercalated (inserted) graft is useful to correct the flexion deformity, usually through a volar approach.

Once the arthritic process has begun, the goal shifts from achieving union at the fracture site to maximizing strength and providing pain relief by some type of salvage procedure. If the associated degenerative arthritis is limited, options include scaphoid proximal pole excision, radial styloidectomy with wrist denervation, scaphoid excision and four-corner fusion or PRC (Proximal Row Carpectomy). PRC is usually not indicated if there is any lunocapitate arthritic involvement, but this is usually the easiest procedure to perform for the non-hand surgeon. If the wrist arthritis is advanced, total wrist arthrodesis is indicated.

Difference of opinion exists regarding the development of osteoarthritis in cases of longstanding nonunion, whether symptomatic or not. Most authors feel that unstable fracture non-unions will progress to increased carpal instability, collapse and osteoarthritis.

Unless there is evidence of osteoarthritis, such procedures as radial styloidectomy, implant arthroplasties, carpectomy or arthrodesis should not be considered. Limited arthrodesis could be useful in failed bone graft procedures, in heavy laborers or for the very active.

**Fractures of the proximal third of the scaphoid**

Acute proximal pole fractures deserve special mention in that they have a high rate of avascular necrosis and may be best treated with operative fixation. These fractures are more easily approached dorsally, allowing exposure and fixation of the proximal pole, with or without primary bone grafting.

If prolonged healing time is suspected, due to the nature of the fracture, primary bone grafting should be considered. Due to the absence of sufficient vascular foramina, 30% of these fractures could develop avascular necrosis of the proximal fragment or even fracture nonunion.
Although avascular necrosis may delay union, it is not necessarily a sign of impending nonunion. Fresh non-displaced fractures can be treated by cast immobilization, but the time of immobilization is controversial. Although the time of healing is known to be prolonged, prolonging immobilization beyond 12 weeks does not seem justified. The surgical method of treatment depends on the size of the proximal fragment. When this comprises one-third of the scaphoid, bone grafting by Russe's method with K-wire fixation may be successful. In smaller fragments, Math's technique, with K-wire fixation across the fracture and the scapholunate joint, is preferable. In cases of symptomatic nonunion or very small fragments, the fragment can be excised, the space filled by a tendon graft and possibly a triscaphe fusion used to stop carpal migration. The latter procedure is difficult and not recommended in our hospitals without experience.

**Fractures of other carpal bones**

Isolated fractures of the other carpal bones are less frequent than those found in combination with other carpal injuries. Dorsal chip fractures are also more commonly seen than fractures involving the bodies of specific bones. Chip fractures, especially of the triquetrum, caused by dorsal shear stresses are easily seen on lateral radiographs and are relatively easily managed by cast immobilization or by the later excision of fragments if symptomatic.

Most acute fractures of carpal bones are treated by protective splinting for 6 weeks. Non-unions and avascular necrosis are rarely seen.

Specific problems related to specific carpal bones can be summarized as follows:

**Pisiform**

In cases with persistent pain and those with degenerative changes in the pisotriquetral joint, excision of the pisiform is a gratifying procedure.

**Trapezium**

Fractures of the ridge that continue to be symptomatic after splinting, or threaten the median nerve, may be treated by excision of the fragment.

**Capitate**

Strictly isolated fractures are rare. The capitate is more susceptible to fractures through the neck, frequently in association with fracture-dislocations of the scaphoid and carpus. Avascular necrosis in isolated fractures is unusual but non-unions may occur.

**Hamate**

Hook-fractures result from a fall or the direct force of the handle of a work tool or sport implement, as a golf club. The chronic case is easily diagnosed with a carpal tunnel view radiograph, and in the acutely painful case, an oblique view with the forearm in mid-supination and the wrist in dorsiflexion will reveal the fracture. Neuropathy of the deep branch of the ulnar nerve can occur. Healing of the acute fracture with cast immobilization is rare and
excision of the ununited fragment is indicated for persistent pain or symptoms suggestive of ulnar neuropathy.

**Triquetrum**
Uncommon but chip fractures are seen after direct blows or extreme dorsiflexion of the hand. There is swelling of the wrist and tenderness over the triquetrum with radial deviation. Usually seen with standard PA, lateral and oblique x-rays. Splint immobilization for 2-3 weeks is usually sufficient.

![Fig 10 Triquetral fracture](From [www.ORIF.com](http://www.ORIF.com), used by permission)

**Carpal Ligaments:**
Scapholunate ligament tears and perilunate dislocations are the most common and the most important ligamentous injuries of the wrist. Understanding of the underlying anatomy, mechanism of injury causing the tears and dislocations of these structures are essential to arrive at the exact diagnosis in order to treat each injury specifically and effectively.

**Ligamentous anatomy**
The ligaments of the wrist are divided into two major groups.

- **Extrinsic** which course between the carpal bones and the radius, ulna and the metacarpals; e.g. radiocarpal and ulnocarpal ligaments
- **Intrinsic** which originate and insert on the carpal bones;
  - Long: volar intercarpal.
  - Short: bind the four bones of the distal row together

The Intrinsic and Extrinsic Volar Wrist Ligaments:
The Extrinsic Dorsal and Collateral Wrist Ligaments:

I. Sprains (Stable Wrist Injury)

A "sprained" wrist is one of the most common diagnoses made in the upper
extremity. Sprains are injuries to ligaments and can be divided into three grades:

♦ Grade I is a ligament injury with a minor tear.
♦ Grade II is a partial tear or stretch.
♦ Grade III is a complete tear.

Grade I and grade II injuries (also referred to as pre-dynamic injuries – see below) can generally be treated non-operatively and are discussed here; grade III injuries of the wrist may require surgical repair and are discussed in the next section.

It is important in the diagnosis of a wrist strain to keep the possibility of a more severe injury in mind. Significant initial symptoms, persistent signs and symptoms and the lack of response to appropriate treatment should always raise suspicion of a more serious tear.

**Clinical history and presentation:** Wrist sprains commonly occur from a fall on an outstretched hand. Patients present with pain and swelling in the wrist.

**Physical examination** may pinpoint the area of injury; however, the pain is often diffuse. **Stress tests should be normal** both on exam and on x-ray.

**Radiographs** should be taken and special stress tests performed if the physical examination suggests a more serious injury. (See below)

**Treatment** is summarized with the acronym RICE and includes

♦ Rest (immobilization, activity modifications)
♦ Ice (20 minutes every 2 hours)
♦ Compression (gentle compression)
♦ Elevation

This may involve a brace or a cast for 2-6 weeks, minimizing activity that causes pain such as tight gripping or pushing, and anti-inflammatory medications such as ibuprofen. Then a removable brace may be used for activities, as gradual strengthening and stretching is added. Return to normal activities depends on the severity of the symptoms and the type of sport as well as if the athlete can participate in the sport with a cast or brace.

The patient should be re-evaluated for improvement after a period of treatment (2 to 4 weeks).

♦ If the patient's symptoms improve, immobilization should be weaned and a progressive return to activities commenced.
♦ A failure of treatment should prompt further evaluation for occult serious injury. Patients who improve but have lingering symptoms should be re-evaluated after several months to avoid the situation in which the patient with a diagnosis of wrist sprain is found years later to have scapholunate advanced collapse (SLAC wrist).

**Editor’s Note:** simple wrist sprains are quite rare in our patients and most of these injuries will involve a definite ligament tear and these must be carefully looked for. **Ligament tears are best treated early.**
Stress views must be taken to rule out dynamic instability. This would include an A-P view of the wrist with a clenched fist to rule out tears in the scapholunate ligament.

II. Carpal Instability (Unstable Wrist Injury)

Most authors divide intercalated (meaning between carpal bones or rows of bones) carpal instability into that which occurs within a row, termed dissociative, and that which occurs between rows, termed non-dissociative.

Intercalated segment instability, that is instability resulting from injury either between or within the carpal bone rows are divided into dorsal and volar patterns, depending on whether

- the scaphoid flexes and the lunate extends (dorsal intercalated segment instability = DISI) or
- the scaphoid extends and the lunate flexes (volar intercalated segment instability = VISI). (Fig 13)

![Fig. 13](Image)


A. NORMAL Scapholunate angle = 47 degrees. Range = 30-60º. SL angle is created by the long axis of the scaphoid and a line perpendicular to the capitolunate joint.

B. VISI Lunate tilted >15 degrees volarly Scapholunate angle <30

C. DISI Lunate tilted >10 degrees in dorsal direction Scapholunate angle >60º

As seen on neutral lateral views

(From www.ORIF.com, used by permission)

Anatomy of a scapholunate ligament tears:

A scapholunate ligament tear is the most commonly injured wrist ligament and involves, as the name suggests, it is the connecting ligament between the scaphoid and lunate bones.

(Editor’s note: When repeat x-rays 2-4 weeks after an injury fail to show the suspected scaphoid fracture, one must look for a scapholunate ligament tear as the cause for persistent pain.)

This ligament is the most important intrinsic ligament of the wrist binding the scaphoid and lunate bones of the wrist together. It is divided into three
areas, dorsal, proximal and palmar, with the dorsal segment being the strongest portion. It is the main stabilizer of the scaphoid.

Normally, the scaphoid and the lunate move together with the intact scapholunate ligament holding them together – an important factor in the stability of the wrist.

When a scapholunate ligament tear occurs, the scaphoid flexes and the lunate extends (DISI) and a gap may form between the bones (Fig 13). With the volar intercalated segment instability (VISI) the lunate flexes volarly and the scaphoid extends (in Fig 13 – notice the position of the lunate and the line perpendicular through the lunate). This occurs with a combination of a lunotriquetral ligament tears, volar radiolunotriquetral tears and in addition some degree of dorsal radiotriquetral ligament tears—and not just an isolated lunotriquetral ligament tear.

A scapholunate ligament tear can vary from mild sprains (partial tears, Grade I) to complete tears (Grade III) with or without other ligaments torn. They may also be accompanied by other injuries such as a scaphoid fracture or a lunate dislocation. (See below.)

The scapholunate ligament tear is divided into four categories from mild to severe: pre-dynamic, dynamic, static, and scapholunate advanced collapse.

The Stable wrist injury Grade I or II:
- **Predynamic, or occult, injury**: the mildest form of the scapholunate ligament tears. It is a partial tear of the ligament. X-rays are normal but the partial tear may be visualized by an MRI or by looking in the joint with an arthroscope at the time of surgery.

*Editor’s Note: This will not be diagnosed in most of our hospitals but may be the cause of persistent wrist pain with a negative x-ray.*

Therefore, this is the recommended sequence of care.

1. Original x-rays—if negative for fracture or obvious dislocation, splint or cast wrist for 2 weeks
2. After 2 weeks repeat x-ray, if fracture or dislocation, treat appropriately as discussed in this chapter
3. If the repeat x-ray is negative
   - If there is definite improvement, allow patient to begin daily activities and continue splinting as necessary
   - If patient still has pain and swelling or returns later with persistent pain, then this may be a dynamic scapholunate dislocation or other dynamic injury—see below
4. Stress views must be taken
   - If negative, then continue splinting
   - If patient is unimproved after 2-4 more weeks, then re-evaluate, repeat x-rays and consider referring if this is possible
The **Unstable Wrist Injuries**: Grade III:

- **Dynamic injury**: the ligament is completely torn or stretched to the point that it is non-functional. There may also be some mild injury to other surrounding ligaments. **Regular x-rays are normal but stress x-rays** show a gap between the scaphoid and the lunate.

- **Static injury**: the ligament is completely torn and some of the surrounding ligaments are also injured. **Routine x-rays show a gap** between the scaphoid and the lunate.

- **Scapholunate advanced collapse (SLAC) injury**, the ligament is completely torn, and the injury has been there a long time (years) causing arthritis, or evidence of cartilage damage. It is seen on regular PA x-ray with gapping between the scaphoid and the lunate. This is a predictable pattern of arthritis that develops with longstanding, untreated ligament injuries. (This is different than the SNAC wrist seen after scaphoid non-unions.)

**Symptoms**

A scapholunate ligament tear is usually caused by a fall or by a sudden load on the wrist as with the sprain injury. Sometimes the patient may not recall the fall because they didn’t seek treatment immediately, but only sought treatment weeks later when they continued to have pain. There may be pain in the center or on the radial side of the wrist, especially with activities that load the wrist. There may also be grip weakness, snapping, swelling, or popping.

With examination, the scapholunate interval may be tender and swollen. The **Watson scaphoid shift test** can be helpful: this is done by having the patient ulnar deviate the wrist and then examiner applies dorsally directed pressure to the scaphoid from the palm as the wrist is radially deviated. The dislocated scaphoid will protrude dorsally and then relief of pressure will allow the scaphoid to slip back into place with a clunk. However, this test may be positive in many normal wrists, so it must be interpreted with caution and compared to the opposite side.

**Differential Diagnoses of persistent wrist pain:**

- occult ganglion cyst
- posterior interosseous nerve neuroma
- ulnar translocation
- physiologic scapholunate separation such as lunotriquetral coalition (compare to other hand)

There are several imaging studies that may be used: standard x-rays, stress x-rays, and MRI.

**Standard x-rays** rule out other problems such as fractures. If the patient has a **static injury** (ligament is completely torn), the standard x-rays will show gapping between the lunate and scaphoid (Terry Thomas Sign. Fig 10) and increased angulation between the scaphoid and the lunate. If the patient has a longstanding tear with a **SLAC wrist**, arthritis may be seen on the x-rays.
If standard x-rays are normal, then with a **dynamic injury, stress x-rays** may be useful to show gapping or instability that is too mild to show up on standard x-rays. Stress x-rays include the following views: an AP wrist with a tight fist, a PA wrist with ulnar deviation, and a PA in radial deviation. The physician may also order an x-ray during which the fingers are gently pulled on. These x-rays may show gapping or abnormal angulation that only occurs during activities and **not** when the wrist is at rest. X-rays of the normal wrist may be taken for comparison.

(Where available, MRI and wrist arthroscopy may be very useful to clearly define the injury. **[Editor's Note:** It is understood that most of the surgeons that this publication is intended for will neither have MRI nor arthroscopy capabilities.])
Treatment:

A. Intercalated segment instability: dissociative (Carpal instability that occurs within a row - Grade III tears)

Scapholunate Dissociation

Indications for Surgical Treatment

♦ If there is gapping and increased angulation between the scaphoid and lunate on x-rays (DISI and VISI if there was a perilunate dislocation), or if treatment without surgery hasn’t been successful, then surgery is warranted.

♦ If the x-rays don’t show gapping, but treatment with a cast or brace has not been successful, surgery might be necessary. *(It will be a rare occurrence for this to be done in a district hospital without some definite findings. In this situation, unless one has considerable experience, it would be best to have the patient go to the capital city or medical school for an MRI/arthroscopy—if such is available there.)*

♦ If significant instability is present, pins may be placed to hold the bones in place and/or reconstruction of the ligaments—an open procedure and best performed in the first weeks after injury.

♦ If x-rays *show gapping, as in dynamic or static injuries*, then surgery is warranted. This involves repairing the ligament. The ligament will be difficult to repair after several months. The pins are usually placed to help protect the ligament repair while it is healing. After surgery, a splint is placed which is then changed to a cast at 1-2 weeks. The cast protects the repair as well as the pins, which are protruding through the skin. The pins are removed at 10-12 weeks after surgery. Then range of motion and strengthening exercises are begun. *(If one reaches this stage and feels confident with wrist anatomy and surgery, then one must consult major hand texts to learn the appropriate hand therapy or consult with the editor of this book.)*

♦ There are several new and advanced techniques for SL ligament repair which are beyond the scope of this chapter.

♦ If x-rays show *gaping and arthritis or collapse of the carpal bones, ligament repair is not likely to work*. Treatment without surgery may be indicated because surgical options are more involved and would involve a Proximal Row Carpectomy or wrist arthrodesis. In this situation, treatment without surgery may involve bracing, anti-inflammatory medications, avoiding painful activities, and cortisone injections. In time, the patient will likely require surgery.

Methods of Treatment

♦ Closed reduction and casting alone are inadequate for long term treatment of these injuries.

♦ Open reduction through a dorsal incision in the center of the wrist with ligament repair, and pinning remain the mainstay of treatment for acute scapholunate ligament tears. Cast is applied for 6 weeks.
♦ **Technique:** A typical dorsal longitudinal incision for wrist surgery is carried out between the 3rd and 4th dorsal compartments. The EPL will be freed from its compartment and reflected radially. Only in the acute case will one be able to repair these ligaments. Any DISI deformity has to be corrected and the scaphoid and lunate pinned or screwed together. Bone anchors can also be used to repair the ligament by inserting anchors in both bones and tying the sutures together. K-wires (0.045 or 0.062) can be passed into the scaphoid and lunate under direct vision to be used as “joy sticks” so that the bones can be aligned properly for the ligament repair. After the ligament has been repaired, two similar K-wires should be passed between the scaphoid and lunate and one or two between scaphoid and capitate for stability.

♦ One may view the technique of dorsal capsulodesis below in a text and add it to this procedure.

♦ **This problem is commonly recognized late** (>3 months), and ligament repair may no longer be possible. In this case, several treatment options exist. Simple débridement may be adequate for partial tears. **The technique above can be done. The techniques below are difficult and mentioned only for completeness.**
  - Ligament reconstruction can be performed with a tendon graft. Bone-ligament-bone reconstruction is appealing and has proved successful in other orthopedic applications, such as anterior cruciate ligament reconstruction of the knee. Potential sources of bone-ligament-bone tissue include hamate metacarpal joint and the cuneonavicular ligament from the foot.
  - Dorsal capsulodesis alone or combined with a reconstruction can limit flexion of the scaphoid. **(not recommended for most institutions)**

♦ Once the **arthritic process** has commenced, a partial wrist fusion may be indicated. Fusion of the scaphotrapezial-trapezoid, scapholunate, scaphocapitate, and scaphocapitotriphalangeal joints has been described; however, **proximal row carpectomy (PRC)** may afford good pain relief and potentially improved motion compared with a partial wrist fusion, although this remains somewhat controversial. Proximal row carpectomy remains a viable option even in the presence of capitate base arthrosis as long as a strip of dorsal capsule is interposed between the capitate and radius—a fascial arthroplasty.

♦ **Treatment Options for Chronic Tears and arthritis:**

If sophisticated surgery is not possible then conservative management with splinting and pain relief should be the aim. If pain becomes unacceptable then PRC or wrist arthrodesis is indicated. PRC is a wonderful and relatively easy operation. Limited arthrodesis procedures mentioned above would be difficult for a surgeon not trained in hand surgery. See wrist arthrodesis technique below.
B. Dorsal Perilunate Dislocations:

This is a severe wrist dislocation that can easily be missed. With severe trauma the same forces on an outstretched hand that led to a scapholunate ligament tear can also lead to further ligament injuries including lunotriquetral ligament tears. If these occur together then the final stage of this injury pattern is the dislocation of the lunate. The lunate may dislocate completely when all the restraining ligaments are torn except radioscapholunate. Residents may miss this diagnosis on routine x-rays in the Casualty Department. This is the most severe wrist dislocation and it is sometimes associated with a transscaphoid fracture and a fracture through the neck of the capitate.

Fig. 17
PA x-ray: wrist does not look right but difficult to diagnose

Fig. 18
Lateral view is not clear unless one notices the dislocated lunate with the “spilled tea cup” sign

Fig 19     Fig 20
Perilunate Dislocation Not as severe as in case above—easier to miss

**Diagnosis**

The patient often has severe pain and on exam there is significant swelling and pain on motion. Patients may have median nerve symptoms since the lunate may be displaced into the carpal canal as in Figure 18. It is difficult to make the diagnosis on exam alone but basic PA and Lateral x-rays should give the diagnosis.

There is a spectrum of lunate dislocation in the so-called Lesser Arc Injury pattern through the scapholunate and lunotriquetral ligaments. The patient above had a Stage IV perilunate dislocation with rupture of the palmar capsule—giving the lunate the appearance of a “spilled tea cup. See blue arrow in Figure 18 above.

These dislocations are difficult to reduce and the above injury pattern could not be reduced closed as the lunate was outside the volar wrist joint capsule. This patient required operative intervention.

**Treatment**

**Closed Reduction**

An attempt should be made to reduce all ACUTE (seen within hours after the injury) injuries using Tavernier’s method. You will likely never see an acute case. After 10 minutes of elevation and uninterrupted traction with finger traps, then under complete anesthesia, regional or general, and with the wrist extended, one hand maintains the traction while the thumb on the hand stabilizes the lunate on the palmar surface. The wrist is gradually flexed allowing the capitate to snap back over the lunate. If this occurs, the wrist is gradually extended while the thumb continues pressure over the lunate. X-rays are then repeated. If there is near perfect reduction with normal angles and a scapholunate gap of less than 3 mm, then dorsal and volar splints are applied as in a sugar-tong splint. Frequent x-rays are taken to ensure reduction. The wrist is immobilized for at least 12 weeks.
Open Reduction

Closed reduction was described since many will not be capable of open reduction; however, open reduction will be needed in most cases and especially since most will come in late. Open reduction involves using both dorsal and volar approaches in most cases. The wrist joint can be opened dorsally as described earlier in this chapter. Often with wrist extension for a few minutes the lunate can be reduced similar to the technique above. When this is not possible the lunate may have herniated through the volar capsule and caught in the carpal tunnel. This requires a volar incision with a carpal tunnel release and then reduction of the lunate. Though dislocated, in most cases the lunate is still attached to some soft tissue and often the short radioscapoholunate ligament (Ligament of Testut) and it will still be viable in most cases.

When the lunate is reduced, the volar capsule is repaired. If the scapholunate and lunotriquetral ligaments can be found, then they should be repaired after K-wires are placed across the joints—scaphoid to lunate, triquetrum to lunate and scaphoid to capitate. The K-wires are placed percutaneously. If the ligaments are not suitable for reconstruction (often the case) the lunate can be held in reduction and two K-wires can still be placed across each joint. In addition, suture anchors if available may be placed in all three bones and sutures tied down as artificial ligaments. The dorsal capsule is repaired. The skin is closed in one layer, preferably with absorbable sutures.

If there is an associated transscaphoid fracture, it should also be pinned. The patient is placed in a short arm thumb spica cast for 6 weeks. The pins are then removed and the cast reapplied for 2 more weeks. Then the patient is placed in a splint and if the x-ray is satisfactory, gentle range of motion is begun.

On occasion, an older patient will present late with a chronic complete lunate dislocation and the lunate cannot be reduced without tearing surrounding scar and what tissue remains. In such cases a proximal row carpectomy is a good solution. No healing of ligaments or bone is necessary and the patient
can start motion in a few days. This would only be done in late cases with an avascular displaced lunate in the carpal canal. One should always exam the patient for carpal tunnel impingement and release the carpal tunnel if indicated.

C. Intercalated segment instability: non-dissociative (Carpal instability that occurs between rows)

When the instability is between the proximal and distal rows, both dorsal and volar intercalated segment instability deformities can occur. It is often associated with ligamentous laxity. A painful clunk may be palpated with radio ulnar deviation of the wrist.

Treatment

Treatment is usually conservative, but mid-carpal arthrodesis may be indicated for those unresponsive to non-operative management. If the laxity is secondary to an underlying deformity, this will need to be addressed first (e.g., corrective osteotomy for a distal radius malunion).

Proximal Row Carpectomy

Proximal Row Carpectomy is a relatively easy salvage procedure for chronic unsalvageable wrist pain and indicated in:

♦ Disabling wrist pain, secondary to SLAC wrist
♦ Kienbock’s disease
♦ Scaphoid Nonunion or avascular necrosis (AVN)
♦ Acute and subacute severe carpal fractures and dislocations

Contraindications

Severe degenerative changes in the head of the capitate—relative as one may be able to place dorsal capsule between the capitate and radius. This is a fascial arthroplasty and works well in most cases.
Rheumatoid arthritis
Patients >35y/o are more likely to require revision surgery (fusion).

Wrist arthrodesis is an alternative to when proximal row carpectomy is contraindicated.

The Technique for Proximal Row Carpectomy

♦ Well-padded tourniquet placed high on the arm
♦ Longitudinal incision centered on radiocarpal joint from ulnar side of radius to the base of 2nd metacarpal.
♦ Dissection under 2.5x/3.5x loop magnification, if available, and identify the extensor retinaculum. Incise longitudinally, opening the 4th extensor compartment. Preserve cuff of retinaculum for later repair.
♦ Identify and release EPL from third dorsal compartment
♦ Isolate and retract extensor tendons with Penrose drain.
♦ Identify the posterior interosseous nerve in floor of the 4th dorsal compartment and transect proximally.
♦ Perform T-capsulotomy centered over scapholunate joint - note dissociation of scapholunate ligament, degenerative changes in radioscaphoid joint etc
♦ Preserved cartilage of the capitate.
♦ **The bones should be removed in the following order:**
  ♦ Place a Steinmann pins in the lunate and excise lunate.
  ♦ Place Steinmann pin in the triquetrum and excise.
  ♦ Divide the scaphoid at its waist with in osteotome. Excise distal fragment using a threaded Steinmann pin as a joy stick.
  ♦ Protect and verify the integrity of the radioscaphocapitate ligament.
  ♦ A radial styloidectomy may be performed with dissection between the 1st and 2nd dorsal compartments. Remove distal 5 to 7 mm of radial styloid. Ensure that the radioscaphocapitate ligament is preserved.
♦ Irrigate.
♦ Repair capsule to maintain capitate in lunate fossa.
♦ Repair extensor retinaculum and close in layers.
♦ Apply a volar splint in neutral and elevate the hand
♦ Some will place a pin through radius and into capitate for several weeks

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For all chronic conditions resulting in severe pain and/or significant functional limitations, proximal row carpectomy or wrist fusion works well. The techniques are described below:

**Follow-up care**

♦ Wound check at 7-10 days
♦ At 4 weeks the splint is removed and X-rays done. Start gentle strengthening exercises and functional activities. Apply a cock-up wrist splint as necessary for light duty work. No heavy manual labor
♦ Full activities at 3 months: may resume manual labor if adequate strength has been achieved.

**Proximal Row Carpectomy Complications**

- Degenerative changes in the radiocapitate articulation.
- Stiffness, motion loss.
- Weakness.
- CRPS—Complex Regional Pain Syndrome
- Continued pain.
- Instability.
- Degenerative changes in the radiocapitate articulation

**Technique of Wrist Fusion** *(This assumes the surgeon does not have special reconstructive plates and screws)*

- Well-padded tourniquet placed high on the arm
- Longitudinal incision centered on radiocarpal joint from ulnar side of radius to the base of 2nd metacarpal.
- Dissection under 2.5x/3.5x loop magnification (if available) and identify the extensor retinaculum
- Incise longitudinally, opening the 4th extensor compartment. Preserve cuff of retinaculum for later repair.
- Identify and release EPL from third dorsal compartment
- Isolate and retract extensor tendons with Penrose drain.
- Identify the posterior interosseous nerve in floor of the 4th dorsal compartment and transect proximally. The nerve is beneath the tendons.
- Transverse incision through the wrist capsule and reflect the capsule distally or a reverse T incision can be used
- Using an osteotome or a large rongeur, remove all the cartilage from the articular surface of the radius, scaphoid, lunate, triquetrum, capitate, hamate and 3rd CMC joint.
- One may perform a Proximal Row Carpectomy first to make the arthrodesis easier. The bones may be morselized and used for bone graft.
- Steinman (3mm) pins may be placed percutaneously and laterally along the shaft of the 3rd MC and then obliquely through the base of the MC and into the carpus. They can be left protruding for 2-3 months or better left under the skin with the end bent so that they do not migrate proximally. They can then be removed in 3 months or left permanently.
- If one has a way to countersink the Steinman pins, they can be inserted into the 3rd MC head down into the carpus and then into the distal radius. An additional pin may be necessary through the 4th MC head. The pins are cut off close to the MC heads and countersunk 15 mm into the distal MC so they do not back out.
- Most will use the previous method that does not require one to countersink the pins.
- There is less chance for infection when the pins are buried.
♦ An attempt is made to slightly extend the wrist while inserting the pins
♦ The wrist is casted for at 12 weeks or until there is evidence of healing.

(Editor’s Note: A simplified approach to the injuries in district hospitals is simply this: Acute ligamentous tears whether isolated to the scapholunate ligament or lunate/perilunate dislocations can be treated with open reduction and repair w/ k-wires and casting. Chronic injuries that result in instability with or without arthritis, avascular necrosis, collapse, or significant functional limitation should be treated with proximal row carpectomy or total wrist fusion.)