INTRODUCTION
Scaphoid fractures are common in an active population and are notorious for being difficult both to diagnose and to treat. The potentially serious consequences of a non-united scaphoid fracture with progressive osteoarthritis and carpal collapse, so called SNAC (Scaphoid Non-union Advanced Collapse), has resulted in restrictive treatment protocols with long immobilization. A majority of scaphoid fractures are, however, non-displaced and have a good prognosis and often require limited time of immobilization. On the other hand, displaced and comminuted fractures may benefit from early surgical treatment. Thus, it is of great importance not only to diagnose these fractures when suspected, but also to classify them correctly to limit the risk of both over- and under-treatment. Choosing the optimal treatment is especially challenging in athletes, where the wish for a fast return to sports may be in conflict with the risks for complications in a longer perspective. When treating an athlete with a scaphoid fracture it is important to recognize that different sports place different demands on the hand and wrist. In addition, the possibilities to participate in different sports wearing a cast or orthosis vary depending on different regulations. Another issue that may affect treatment is when in the season the injury has occurred.

EPIDEMIOLOGY
The scaphoid is the most commonly fractured carpal bone with an incidence of 29-43 fractures / 100,000 persons/year. In a military population an incidence of 121 / 100,000 person/years is reported. A 1-year survey at the Methodist Sports Medicine Center, Indianapolis USA, found that scaphoid fractures accounted for 19% of all fractures. They found that especially football and basketball players were at risk. 1% of college football athletes are estimated to sustain a scaphoid fracture, and as high as 2% of snowboarders.

Most common mechanism of injury is a fall on an outstretched hand. Fractures in the middle third, the waist, of the bone accounts for approximately 2/3 of fractures, and 60-85% of these are non-displaced. Distal fractures represent 25%, while 5-10% occur at the proximal third. The so called “Goalkeeper injury” deserves to be mentioned, it is a proximal fracture following a forced hyperextension when stopping a ball, typically in soccer or handball.

CLASSIFICATION
All available systems for classification of scaphoid fractures are based on conventional radiographs. The most used system, Herbert’s classification, is based on expected fracture instability, where all bicortical fractures are considered unstable and candidates for internal fixation. We find that this view might lead to overtreatment.

The Mayo classification, used in these guidelines, is based on fracture location, where the scaphoid is divided into thirds. It gives a simple morphological description which we find useful in a clinical setting.

DIAGNOSIS
Clinical investigation
Posttraumatic radial wrist pain should always evoke the suspicion of a scaphoid fracture. The three most commonly used clinical test are: anatomical snuff box tenderness, scaphoid tubercle tenderness and pain on axial compression of the thumb. If all tests combined are positive...
the sensitivity has been reported to be 100% and the specificity 75%. Pain on axial compression of the thumb has been demonstrated to have the weakest diagnostic performance.

**Radiological investigation**

When a scaphoid fracture is suspected a conventional wrist radiograph must always be supplemented with 3-4 special projections of the scaphoid. Nonetheless the sensitivity with conventional radiographs is not higher than 70%. Radiographs are also poor for fracture classification.

If a scaphoid fracture is suspected but not visible on radiographs, an early MRI is recommended. MRI has a sensitivity of 99-100% and has been shown to be cost-effective compared to immobilization and repeated radiographs. In addition an MRI in a patient with radial sided wrist pain can detect also other injuries besides a scaphoid fracture.

CT, with the possibility for reconstruction of the images in the long axis of the scaphoid, gives the best possibility to evaluate fracture displacement.

If a fracture is only detected on MRI, or is only visible as a hair thin line on radiographs, we do not perform a CT, but if the fracture is clearly visible on all projections, displacement and instability can be suspected and we recommend a CT for fracture classification.

Increased displacement increases the risk for fracture instability. However, also non-displaced fractures can be unstable, for example non-displaced fractures with a small radial fragment, are often unstable.

(Figure 1)

**TREATMENT**

**Negative MRI**

Patients with suspected scaphoid fracture where the MRI turns out negative can be mobilized immediately. It is however of vital importance to clinically evaluate these patients for any signs of scapholunate, SL-ligament injury. MRI can’t exclude ligament injury, and if a SL-injury is suspected an arthroscopy within 6 weeks after trauma should be performed.

**WAIST FRACTURES**

90% of non- or minimally displaced waist fractures (0.5-1.5mm) are healed after 6 weeks in a cast. Geoghegan et al. have demonstrated that it is possible to mobilize a non-displaced fracture already at 4 weeks, if a CT doesn’t oppose ongoing union. Those that have not healed after 6 weeks often heal with additional 4 weeks immobilization. Generally, a waist fracture with a displacement >1mm has been considered unstable and thereby candidate for internal fixation. We have previously demonstrated that fractures with a displacement < 1.5mm on CT united uneventfully in a cast, although with fixations times up to 14 weeks.

Operative treatment should also be considered in cases of comminution (Figure 3). DISI-pattern instability, lateral intra-scaphoid angle > 35°, and for all fractures part of a peri-lunar injury. For the competitive athlete a displacement of 0.5-1.5mm is a relative indication for surgical treatment.

**Surgical treatment of non- or minimally displaced waist fractures**

For athletes, surgical treatment of nondisplaced fractures is often recommended in order to have a faster return to sports. Randomized trials have shown short-term advantage of operative treatment in form of a few weeks earlier return to work or sports. However, internal fixation is associated with a higher complication rate in terms of protruding hardware, infection and scar related problems, and may be followed be an increased long-term risk for development of osteoarthritis. Most studies comparing conservative and surgical treatment have included their patients based on conventional radiographs which we know underestimate the displacement of the fracture. Hence, the previous studies probably include a mix of nondisplaced and moderately displaced fractures. Also, most previous studies have had long periods of immobilization for their conservatively treated patients. With the protocol we present here, with CT based classification and CT verified union, it is possible to sort out the true nondisplaced fractures with a better accuracy, and to shorten the period of immobilization for the conservative treatment. This probably makes the difference in time to union between surgical and conservative treatment of nondisplaced fractures even less. The benefits of surgical treatment of a minimally displaced fracture for most recreational athletes are small and do not, in our opinion, justify the risk.

Figure 1: A non-displaced waist fracture with a small radial comminuted fragment. This fracture pattern is associated with fracture instability and should be further evaluated with CT. From Buijze 2012, with permission from Elsevier.
WRIST INJURIES

Scaphoid waist fractures

Classification and treatment are based on CT in cases with fracture displacement or comminution

<table>
<thead>
<tr>
<th>NON-DISPLACED FRACTURE</th>
<th>DISPLACED FRACTURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤0.5 mm</td>
<td>0.5 – &lt;1.5 mm</td>
</tr>
<tr>
<td>1. Comminuted fracture 1. Comminuted fracture</td>
<td></td>
</tr>
<tr>
<td>2. Reduced compliance  2. DISI alignment</td>
<td></td>
</tr>
<tr>
<td>3. Smoking              3. Intra-scaphoid angle &gt; 35°</td>
<td></td>
</tr>
<tr>
<td>Short arm cast for 6 weeks Short arm cast for 10 weeks</td>
<td></td>
</tr>
<tr>
<td>Short arm cast for 10 weeks Operative treatment</td>
<td></td>
</tr>
</tbody>
</table>

Figure 2: Treatment algorithm for scaphoid waist fractures. From Clementson, 2020, with permission.

Figure 3: A) Below elbow cast with no immobilization of the MCP-1 joint. B) An example of a wrist brace which can be used as a playing cast.

the professional athlete who can’t compete with a brace, each week is important, and surgery can be considered. Surgical risks have to be taken in account, but also where in the season the injury occurred and the schedule of any coming games or tournaments. Not even surgical treatment allows for immediate return to play, and although surgically treated patients can be mobilized earlier there are indications that conservatively treated patients may have a better mobility in a long term perspective.

PROXIMAL FRACTURES

Fractures in the proximal third of the scaphoid are often unstable which, in combination with a tenuous blood supply, increases the risk for delayed- and non-union. Conservative treatment has been reported to result in a non-union rate of 10 to 14% for non-displaced fractures and as high as 50% for displaced fractures. A distinction between non-displaced and displaced fracture is crucial, and we recommend CT investigation for all proximal fracture and internal fixation if displacement is found. However, based on CT, non-displaced fractures without signs of instability and not being part of a high energy trauma can be considered for conservative treatment, but with prolonged immobilization for 8 to 10 weeks.

DISTAL FRACTURES

The distal third of the scaphoid is well vascularized and fractures in this part of the scaphoid are often non- or minimally displaced and heal uneventful with conservative management. An avulsion of the radio-volar tip of the tuberosity with non- or minimal articular involvement is the most common fracture type and accounts for more than 50% of all distal fractures. These fractures are sufficiently treated with 4 weeks immobilisation in a short arm cast or orthosis. The second most common fracture type of the distal scaphoid is an intra-articular fracture in the radial half of the joint surface caused by compression or shearing forces through the trapezium. A prolonged immobilization for 4 to 6 weeks is recommended. In rare cases, a comminute fracture pattern which involves the entire articular surface of the distal scaphoid is found. In such cases, we recommend a short arm cast with immobilisation of the thumb for 4 to 6 weeks.
From radiographs it can be difficult to assess displacement and congruency of the distal articular surface. CT is therefore of value if fracture displacement is suspected. If severe displacement is found, operative treatment may be considered.

**SURGICAL TECHNIQUE**

For waist fractures a volar approach is generally preferred\(\textsuperscript{43}\).

For moderately displaced fractures we recommend a percutaneous retrograde fixation. This leaves the cartilage of the proximal pole undamaged. Reduction of the fracture is often accomplished by extension and ulnar deviation of the wrist.

In cases with severe dislocation or instability, an open technique can be necessary. The volar approach gives an excellent access to the bone facilitating fixation and makes fracture reduction easier than when using a dorsal approach, where you have to flex the wrist, and also risk injuring the dorsal blood supply. When a volar approach is used it is important to meticulously suture the radio-carpal ligaments to avoid future instability\(\textsuperscript{44}\).

Arthroscopic assisted retrograde fixation is an optional alternative for waist fractures. It has the advantages of direct visualization and control of the fracture and reduction, and to verify that the screw does not penetrate the proximal cortex. It also enables direct evaluation of any concomitant ligament injury. Especially in severe displaced fractures, arthroscopic fixation can be technically demanding and should only be performed by surgeons experienced in wrist arthroscopy.

Fixation with two screws antegradely has been suggested as this gives additional stability to the fixation in an experimental setting\(\textsuperscript{45,46}\). Whether this extra stability is clinically relevant is debatable. Yildirim with colleagues still recommend a careful postoperative regime and full axial load non sooner than 6 months postoperative. Given the small size of the scaphoid bone, a two-screw technique can be hazardous with a risk for splitting the bone, and it leaves a relatively large defect in the proximal pole cartilage. It also leaves less cross-sectional area for the bone to unite. No screws can hold the fracture unless the bone unites, which, in our opinion, can be achieved with one, or none, screw as well.

For proximal fractures, a volar approach may displace the proximal fragment, and

---

**Scaphoid proximal pole fractures**

Fracture classification and treatment are based on CT evaluation

<table>
<thead>
<tr>
<th>NON-DISPLACED FRACTURE</th>
<th>DISPLACED FRACTURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;0.5 mm</td>
<td>≥0.5 mm</td>
</tr>
</tbody>
</table>

Operative treatment | Consider short arm cast for 10 weeks | Operative treatment

Figure 4: Treatment algorithm for scaphoid proximal pole fractures. From Clementson, 2020, with permission\(\textsuperscript{30}\).

**Distal Scaphoid fractures**

Consider CT when severe intra-articular fracture displacement is suspected

<table>
<thead>
<tr>
<th>EXTRA-ARTICULAR AVULSION FRACTURE from the tubercle.</th>
<th>INTRA-ARTICULAR FRACTURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Displacement ≤1.5 mm</td>
<td>Displacement &gt;1.5 mm</td>
</tr>
</tbody>
</table>

Dorsal wrist cast or orthosis for 4 weeks | Short arm thumb spica cast for 4 to 6 weeks | Consider operative treatment

Figure 5: Treatment algorithm for distal scaphoid fractures. From Clementson, 2020, with permission\(\textsuperscript{30}\).
it is also difficult to securely engage the proximal fragment with the leading threads of the compression screw when inserted in the distal-to-proximal direction. Therefore, a dorsal approach is generally recommended. At our institution, we prefer a mini-open technique to visualize the fracture line as it allows a more precise screw placement being as perpendicular to the fracture plane as possible. Small screw diameters such as 1.7 or 1.9 mm should be used to minimize the impact on the proximal cartilage.

ASSESSMENT OF FRACTURE UNION
Bone union should always be assessed by combining clinical investigation of the wrist together with radiological findings. Persistent pain over the fracture site may indicate incomplete or delayed union but may also relate to an associated injury. Still, long-term anatomical snuff box soreness may also relate to an associated injury. In many sports where wrist movement is not primarily involved, such as soccer or some track and field sports, it is possible to return while in a cast or well fitted brace. The National Football League in USA allows players to compete with splints if they are padded. A similar instruction exists for the National Basketball Association. FIFA regulations (soccer) states that it is up to the judgement of the referee to ensure that the protective device does not impose a risk for other players.

A retrospective follow-up of both surgical and nonsurgical treatment of waist fractures in athletes showed comparable union rates and early return to sports in the conservatively treated group using a playing cast.

In sports with more demand on wrist function, such as basketball, hockey and tennis, union should be confirmed with CT before allowing gradually return to full active level. This applies to surgically treated patients as well. In addition, strength and range of motion should have reach 80-90% of the uninjured hand before unrestricted return to full activity is recommended.

In sports requiring a very high load of wrist strength or motion, such as weightlifting, gymnastics and boxing, we recommend a minimum period of 6-12 weeks after union is confirmed before full activity level, for allowing the fracture to thoroughly consolidate.

Scaphoid fractures, when united, usually have a good long-term outcome and most patients report a normal hand function. Having sustained a scaphoid fracture has been shown not to diminish the participation in the National Football League.

SUMMARY
1. For diagnosis, in cases of suspected scaphoid fracture where the initial radiographs are negative, a supplementary MRI should be obtained.
2. Fracture classification, assessment of dislocation as well as evaluation of fracture healing is best done on CT.
3. After adequate conservative management, union is achieved at 6 weeks for approximately 90% of non-
4. or minimally displaced (≤ 0.5mm) scaphoid waist fractures.
5. Most athletes don’t necessarily benefit from surgical fixation of nondisplaced waist fractures.
6. Scaphoid waist fractures with moderate displacement (0.5mm - ≤ 1.5mm) can be treated conservatively. But a risk for prolonged cast immobilization, about 8 to 10 weeks, makes it a relative indication for surgery in athletes.
7. Internal fixation is recommended for all scaphoid waist fractures with dislocation ≥1.5mm.
8. Distal scaphoid fractures can be treated conservatively. The majority heal uneventfully after 4-6 weeks of immobilization, depending on fracture type.
9. In general, proximal scaphoid fractures should be treated with internal fixation.

When deciding the optimal treatment for a scaphoid fracture in an athlete you must take in consideration not only fracture specific factors, but also the type of sport, the level of the athlete, when in the season the injury has occurred and regulations concerning the possibility to return to the sport with a playing cast.

References
Available at www.aspetar.com/journal

Martin Clementson M.D., Ph.D.
Senior Consultant
Institution of Translational Medicine,
University of Lund
Section for Specialised Surgery,
Department of Hand Surgery, Skåne University Hospital SUS
Malmö, Sweden

Anders Björkman M.D., Ph.D.
Professor and Senior Consultant in Hand Surgery
Department of Hand Surgery, Institute of Clinical Sciences
Sahlgrenska Academy, University of Gothenburg
Sahlgrenska University Hospital
Gothenburg, Sweden

Contact: martin.clementson@med.lu.se