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Management of acute scaphoid fractures in athletes

Summary

This paper reviews the epidemiology, diagnosis and both conservative and operative treatment options of acute fractures of the scaphoid, with special regard to the sportsmen. Focus is placed on rapid and accurate diagnosis by the current most sensitive and specific methods. Low-invasive fixation of nondisplaced fractures and costs versus benefits of this approach are presented. An algorithm for diagnosis and treatment of the clinically suspected fracture of the scaphoid is proposed and summarizes our present attitude regarding these lesions.

Questions one should be able to answer after having read this paper:

- Which methods of diagnosis should be preferred?
- Which fracture classification should be used and how should the fracture be described?
- Which type of cast in case of conservative treatment?
- What is meant by «low invasive»?
- Which scaphoid fractures are amenable to low invasive fixation?
- Which nondisplaced fractures of the scaphoid are to be fixed?
- What is the expected outcome after low invasive fixation?
- What are the costs and benefits of low invasive fixation?

Key words:

Scaphoid, fracture, low-invasive, osteosynthesis, athletes

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Incidence and natural history of scaphoid fractures

As in the general population, the scaphoid is the carpal bone most commonly injured in athletes, accounting for at least 70% of all carpal fractures. It is most often encountered in 15 to 30 year-old males and its common occurrence in young athletes makes a high incidence of suspicion essential. As an example, approximately 1% of all college football players in the United States sustain a scaphoid fracture each year [38]. In Switzerland, there is an estimation of around 2000 new cases each year and a prevalence of one case for 3500 inhabitants per year.

Scaphoid fractures can be difficult to diagnose acutely and are commonly missed. The natural history of untreated scaphoid fractures is for the pain to subside gradually, so the athlete may not seek treatment. Later, a second, often light injury causes pain and a scaphoid fracture with delayed or nonunion is diagnosed. If this diagnosis is not made and the fracture is left untreated, natural history studies indicate that progressive radiocarpal and eventually pancarpal arthrosis may ensue. Due to the intracarpal instability associated with scaphoid nonunion, progressive changes, beginning with radiostyloid pointing (2 to 5 years), narrowing of the radioscapoid joint (5 to 10 years), followed by generalized radiocarpal and midcarpal arthrosis (scapholunate-advanced collapse or SLAC wrist, 10 to 20 years), have been reported [21, 32]. One study showed a 2% incidence of arthrosis in wrists with united fractures at 30 years follow-up, compared with a 55% incidence in ununited fractures [8]. It is thus unquestionable that the goal of treatment in acute scaphoid fractures should be to obtain union in an anatomic position.

The importance of early treatment of acute scaphoid fractures is also noteworthy. It has been shown that if treatment is instituted prior to 4 weeks from injury, the union rate is significantly greater than when treatment is started after 4 weeks from injury [18].

When casted within 3 weeks of injury, union rates of 90 to 100% were reported for undisplaced fractures [6]. Stable fractures treated between 6 weeks and 6 months of injury have shown a 90% union rate but the time to union was 20 to 24 weeks, that is approximately twice as much as when the treatment is initiated earlier [22]. In unstable fractures, the union rate for those treated in a cast is only 50 to 60%, whatever the delay in treatment.

Diagnosis

In case of a scaphoid fracture suspected clinically, radiographic confirmation is mandatory. This diagnosis can be difficult, as in acute fractures, the initial plain radiographs are frequently normal. These should include four views: the front and profile views of the wrist and two scaphoid views. In the first, the wrist is dorsiflexed 30° and maximally deviated ulnarly with the forearm in pronation to show the scaphoid in extension («navicular view»). The second is an oblique view with the forearm supinated 45° and the wrist in slight dorsiflexion and ulnar deviation.

Traditional management for clinically suspected, but radiographically negative, acute scaphoid fractures, is to cast the wrist and repeat the same views in 10 to 14 days. In most athletic injuries however, a definitive diagnosis is requested earlier. Further investigational studies such as bone scintigraphy (BS), computer tomograms (CT) and magnetic resonance imaging (MRI) are available to the clinician. Other techniques like X-ray-enlargement [15] or tomograms are obsolete.

Four considerations should direct the choice among these imaging techniques: sensitivity, specificity, usefulness, and costs.

Bone scintigraphy and MRI are both very sensitive [5, 12, 36] and able to provide a positive diagnosis in most instances. The peak sensitivity for BS is from 3 to 10 days after injury [25].

However, it has been shown that MRI is at least as sensitive and is certainly more specific than scintigraphy [34]. MRI not only is the most reliable imaging technique to establish the diagnosis of scaphoid fracture, it is also able to provide useful information regarding its location, displacement or post-traumatic deformity as well as vascularity of the proximal pole (Fig. 1). On the contrary, a positive scintigraphy is nonspecific regarding the exact location and type of fracture. Furthermore, false positive are sometimes observed (scapholunate lesions given as proximal pole fractures).



Figure 1: MRI of an occult scaphoid fracture (negative conventional radiographs).

Although false negative may occur with computed tomography, it has been frequently used in establishing the diagnosis for it gives the best definition of bone cortex and fracture pattern, especially in case of fracture displacement such as in the well-described humpback deformity (volar angulation of the distal fragment). CT scans provide no information about the blood supply of the proximal pole and are far less informative than MRI in this regard. Both techniques require careful positioning in order to get scans along the longitudinal axis of the scaphoid (45° to both the frontal and sagittal planes), which best allow proper assessment of angulation and displacement. It is possible to use short protocol MRI (or CT) and to significantly reduce the time and consequently the costs of these procedures. Applying such a short protocol makes MRI as cost-effective as bone scintigraphy for direct costs and may also contribute to reduce indirect costs by saving time to diagnosis and treatment [14, 35].

Taken together, these points uphold my actual strategy in case of a clinically suspected fracture with initial negative radiographs: a short protocol MRI along the scaphoid axis should be favoured, as it rapidly provides the most sensitive, specific and useful information to treat the fracture appropriately. If the fracture is already visible on plain radiographs, and the presence and extent of displacement and/or comminution are questionable, one may choose between a CT scan or an MRI. If the vascularity of the proximal fragment is the main concern to decide which treatment is most adequate, MRI again should be the first choice.

Classification

There are four main ways to classify scaphoid fractures: by location, fracture orientation, fracture stability and time from injury. All are important in assessing the fracture, its prognosis and how it should be managed.

Fractures of the distal third or tuberosity usually heal without complication within 4 to 6 weeks by conservative means. Middle third fractures are the most common and can be treated orthopaedically when nondisplaced. Fractures of the proximal pole are at high risk of compromised blood supply and consequently, of nonunion.

The classification by Russe (Fig. 2) sorts the scaphoid fractures into transverse, horizontal and vertical oblique, the latter being considered less stable. Fracture orientation may also be relevant in making the decision to fix it operatively or not (see below).

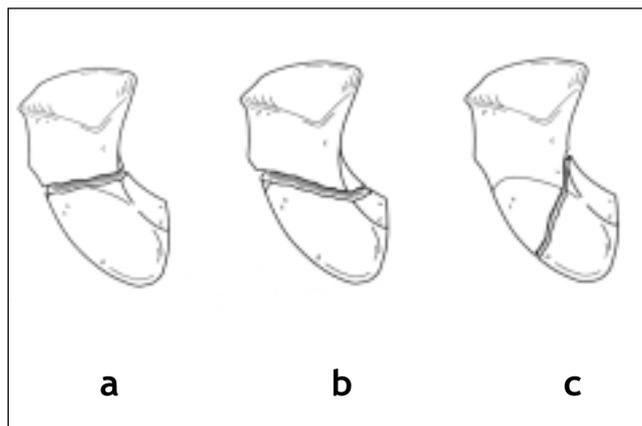


Figure 2: The Russe classification: (a) transverse, (b) horizontal oblique, (c) vertical oblique.

Herbert's classification (Fig. 3) focuses mainly on instability patterns and delay from injury. I found it more comprehensive by adding the A3 pattern to the type A, acute stable fractures. It is a complete but undislocated waist fracture, and probably the commonest among scaphoid fractures. All *type A* fractures may be treated successfully by cast. All *type B* fractures are unstable or potentially unstable and require an operative approach to insure reduction and union. They include: (1) more than 1 mm displaced fractures, (2) vertical oblique fractures, (3) angulated or comminuted fractures, (4) transcaphoperilunate injuries (5) proximal pole fractures. *Type C* fractures are delayed union. *Type D* fractures are established nonunions, either fibrous or true pseudarthrosis.

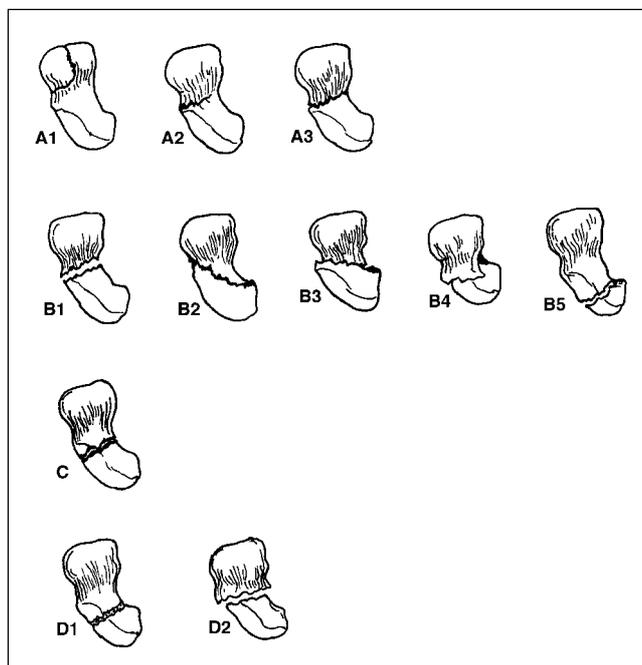


Figure 3: Modified Herbert's classification. A1 to A3: stable fractures, B1 to B5: unstable acute fractures, C: delayed union, D: established non-unions (fibrous and pseudarthrosis).

When classifying a scaphoid fracture, one should define it along the four lines described above: where is it located (tuberosity, waist or proximal pole)? How is the fracture oriented with respect to the longitudinal axis of the scaphoid? Is the fracture stable (not a B1 to B5 fracture)? Is it really an acute fracture? In addition, if the fracture involves the proximal pole, its vascularity should be assessed by an MRI.

Treatment of acute scaphoid fractures

Treatment of acute scaphoid fractures in the athlete is conditioned by various factors, some being dependent on the features of the fracture itself, others being more specific of the athletic conditions, including the desires of the athlete and his entourage. In professional sportsmen, economic considerations become more and more important, whereas the family circle is often very much involved in high-performing amateurs or semi-professionals. In counseling and eventually in making his choice of treatment, it is my opinion that the physician should not forget long-term issues regarding his patient and especially his post-competitive future. Getting the whole picture is essential in making the right choice.

Treatment options are basically as follows: (1) traditional casting and no sports until fracture healing has occurred; (2) cast treatment followed by a playing cast during sport activity during the late period, when applicable; (3) open reduction and internal fixation (ORIF) with return to sports as symptoms permit; (4) low-invasive internal fixation (LIIF), early mobilization and return to sports as symptoms permit.

Conservative treatment

Conservative treatment of scaphoid fractures is usually indicated for nondisplaced waist fractures. Although the average time to union of scaphoid fractures treated nonoperatively is 9 to 12 weeks, a significant number take longer, up to 6 months of immobilization [31]. Traditional cast treatment of nondisplaced mid-third fractures results in nonunion in 5% to 13% of cases, depending on the series [16, 24]. Half the cases of delayed union and nonunion show clinical and radiological signs of malunion, most often by volar angulation of the distal pole of the scaphoid, leading to the so-called «humpback» deformity. Due to the loss of the link-effect of the scaphoid between the first and the second carpal rows, the luno-triquetral block rotates progressively toward dorsal and the classical dorsal intercalated segmental instability (DISI) pattern ensues. This leads to abnormal intracarpal motion [20] and to secondary arthritis, beginning at the radial styloid, in the vast majority of cases (97% at 5 years). The gradual panarthritis and wrist deformity described as Scaphoid Nonunion Advanced Collapse or SNAC wrist results in the mid- to long-term (10 to 20 years).

Conservative treatment is also associated with osteopenia and the relative joint stiffness following long-lasting immobilization. The need to wear a cast for at least 8 to 12 weeks is not always well accepted in the general population and is often felt as a reduction in the quality of life, possibly leading to compliance problems. The wrist not being very painful without a cast, it might be even more difficult to convince the athlete of the necessity to have it casted.

The type of cast has been, and is still to some extent, a matter of controversy [9]. Should it be a long (brachio-antebachial) or a short (antebachial) cast? This issue has been particularly well discussed in the paper by Barton [2]. There is no definitive evidence that a long-arm cast is able to improve significantly the outcome of conservative treatment by reducing the nonunion rate. As for the thumb, which is traditionally included in the so-called «scaphoid cast». As far as the thumb is maintained in a position of function – and not adducted as often observed – its inclusion cannot harm; there is no evidence that it helps however. My own feeling is that the *wrist* must be immobilized by a well moulded cast and that it should be changed and worn properly for the time required. Under these conditions, clinical and radiological union have the best chances to occur. Whatever the type of cast, problems happen when it is not well adapted, not worn continuously or not long enough.

If conservative treatment by cast is chosen, fractures of the distal third (tuberosity) will usually heal by a below elbow cast in 4 to 6 weeks. The most common fractures of the mid-third or waist will require 8 to 12 weeks to get bone union. In the general nonathletic population with a scaphoid waist fracture, the mean time off work is 144 days [24].

An alternative to traditional casting and no sport until fracture has healed is cast treatment plus use of a playing cast for sports participation. This method involves placing the wrist in a thumb spica cast when not practicing, then applying a protective playing cast for participation [30]. US rules permit use of a rigid cast by football players as long as it is covered by a protective foam. Reister et al. reported a 92% healing rate, with an average healing time of 6 months, with this technique [27]. Another study comparing scaphoid fractures treated by cast only or by cast plus a playing cast for sports showed that a high percentage of fractures in the latter group failed to unite without surgical intervention [26]. In the light of these studies, use of a playing cast appears as a bad compromise and compares favourably neither with the rigid but proven-by-practice method of true casting, nor with minimally invasive or conventional open fixation techniques as described below.

Operative treatment

Unstable fractures

Most authors agree that open reduction and internal fixation is indicated and is the treatment of choice for fractures that are displaced and/or unstable [11, 17, 29]. According to the aforementioned classification by Herbert, these are:

- Fractures with displacement of more than 1 mm (B1)
- Vertical oblique or angulated fractures (B2, B3)
- Fractures associated with luxation of the wrist (B4)
- Fractures of the proximal pole (B5)

Displacement may be translational or rotational. In this case, it is usually best visible on the articular surface of the scaphoid facing the capitate. When angulation is suspected (shortening of the scaphoid on the front view and axis disruption on the lateral view), CT scan or MRI are mandatory to fully appreciate the degree of anterior comminution which is usually present. Proximal pole fractures are regarded by most as unstable or potentially unstable fractures. As a matter of fact, they gather two problems: one is their precarious blood supply which commonly leads to delayed union or nonunion; the second is that they mimic or are equivalent biomechanically to a scapholunate injury, leading to an instability within the wrist.

For all these conditions, open reduction and internal fixation are advocated. Without going into technical details, some points deserve to be mentioned. For mid-third fractures, a volar approach is used and anatomic reposition of the fragments is obtained. Internal fixation can be achieved by different means, including Herbert-Whipple, Acutrak and AO cannulated screws. They are usually inserted from distal to the proximal pole. Accurate placement should be sought and constitutes a guarantee for healing [23]. If comminution is present, definitive management must include a volar wedge graft in order to recover the length and shape of the original bone. A free, corticospongious graft from the iliac crest is the gold standard for this purpose. Proximal pole fragments, especially the very small ones, are best exposed and fixed by a dorsal approach. The size of the screw should be adapted to that of the fragment.

Following surgery, the patient is treated with immobilization of the wrist for a varying period of time, depending on the stability obtained at the time of fixation, the degree of compliance which is expected and the healing progress as shown by radiographs.

Stable fractures

As an alternative to traditional casting, low-invasive internal fixation (LIIF) of acute nondisplaced mid-third scaphoid fractures can be proposed to the athlete. From a general point of view, the underlying rationale is threefold: (a) from a medical standpoint, it is to improve the union rate; (b) from an economical view, to reduce the related (particularly indirect) costs; (c) from the patient standpoint, to improve the quality of life, by allowing immediate motion of the wrist.

	Year	Journal	Nb. of patients	Screw	Fracture	Union (%)
Wozasek and Moser	1991	JBJS	198	Cannulated 2.9	All	89
Ledoux et al.	1995	Acta Orthop. B.	23	Herbert	Undisplaced	100
Inoue and Shionoya	1997	JBJS	40	Herbert	Undisplaced	100
Brauer et al.	1997	Unfallchirurg	24	Herbert	All	100
Haddad and Goddard	1998	JBJS	15	Acutrak	Undisplaced	100
De Cheveigne	1998	Abstract GEM	57	Osteo (nC)	Undisplaced	100
Taras et al.	1999	Hand Clinics	5	Herbert	?	100
Adolfsson et al.	2001	JHS(B)	25	Acutrak (C)	Undisplaced	96
Bond et al.	2001	JBJS	11	Acutrak (C)	Undisplaced	100
Total			398			98.3
C:	cannulated					
nC:	non cannulated					

Table 1: Reports of cases treated by minimally invasive screwing.

This method of treatment appears well suited to athletes. In fact, they were among the first to benefit from this approach [28]. The first and largest series using a minimally invasive technique for fixation of scaphoid fractures was published in 1991 [37]. In this series, displaced as well as undisplaced fractures were treated. Since then, several series [3, 4, 10, 13, 19, 33] with more restricted criteria for patient selection have been published (Table 1). Although it is not always easy to assess bone union of the scaphoid [7], the overall union rate using these methods was close to 100%. The more selective were the inclusion criteria (that is exclusion of unstable fractures), the best the results. In addition to this obvious advantage of LIIF over conservative treatment, it was shown in a prospective randomized study that early mobilization was possible without adverse effect on fracture healing [1]. This sets the basis for a more systematic use of LIIF in athletes. Rettig recently reported on a short series of 10 athletes treated by LIIF for acute mid-third fractures with a 3 years follow-up [30]. The union rate was 100%, with return to sport average of 4.4 weeks.

Since 1999, we have prospectively operated and followed 35 patients, including athletes, with our own protocol and technique, using a 3.0 mm self-taping cannulated AO compression screw (Fig. 4). Our goals with this study were to assess technical feasibility and difficulties, patient acceptance, short to mid-term results, as well as to better define indications for this low-invasive fixation technique.

The screw is inserted through a 1 cm transverse volar incision over the scapho-trapezial joint. It is not necessary to open the

joint, but the tuberosity of the scaphoid must be recognized and carefully prepared. The procedure is performed on an outpatient basis. Postoperatively, a short arm splint is applied for three to five days. Mobilization of the wrist is then allowed (Fig. 5). Impact loading, torque and extreme wrist positions are forbidden. Force exercises and load are not allowed for a minimum of six weeks postoperatively or until radiological union of the scaphoid can be established.

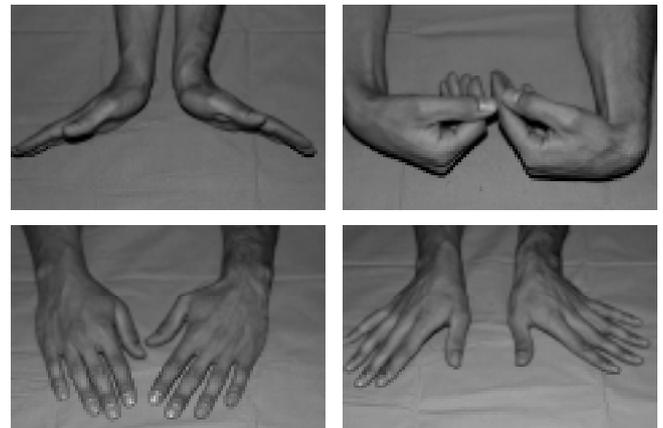


Figure 5: Wrist motion two weeks post low-invasive internal fixation of an acute mid-third scaphoid fracture (right side).



Figure 4: Low-invasive internal fixation (LIIF) technique using the 3 mm cannulated AO screw. Top row: insertion of the guide-wire. Bottom row: screw in place.

All patients except one were males. Mean age was 28 years. Except three slightly displaced fractures, all were of the A2 or A3 types. Seven patients had associated lesions on the same or contralateral side. The average operation time was 47 minutes. Union was achieved in all cases after a mean of 6.5 weeks. Three non-compliant patients required additional splinting to heal. Mean time off-work was 43.5 days (including patients with associated injuries). We had no implant-related complication. Horizontal oblique fractures were found to be a potential problem, as they may translate antero-posteriorly during screw insertion. In addition, as the fracture line is not perpendicular to the screw axis, poor compression may result. The same is true with relatively proximal fractures of the mid-third, which are less stable and may prove difficult to maintain and fix. In such a case, a dorsal approach should be preferred.

A cost-effectiveness study comparing direct and indirect costs of conservative versus low-invasive fixation in a general population was run in parallel. Our data (unpublished, manuscript in preparation) show that direct costs are about twice as high in the operative group compared to the conservative group. Conversely, indirect costs tend to be lower in the operative group, due to the improved union rate and markedly decreased time off-work.

In summary, we found that low-invasive internal fixation of scaphoid fractures was well accepted by the patients as it strikingly reduces the need for immobilization and improves quality of life. It is technically demanding and requires an appropriate instrumentation as well as surgical training. Caution is mandatory

in case of horizontal oblique and proximal mid-third fractures. Thanks to the high union rate, low complication rate and the limited time off-work, it appears as a cost-effective method to treat acute nondisplaced fractures of the scaphoid.

Conclusions

Acute scaphoid fractures in the athlete present some peculiarities in management. However, treatment options are basically the same as in the general population presenting a scaphoid fracture, that is young active males. Figure 6 synthesizes our current guidelines for diagnosis and treatment of acute fractures of the scaphoid.

Most displaced and proximal pole fractures require open reduction and internal fixation by either a volar or a dorsal approach to achieve anatomic reduction (with an iliac crest graft when necessary) and allow for timely healing. Low-invasive fixation may be applicable in some cases with little displacement and no comminution.

Acute, nondisplaced, transverse mid-third fractures (the most common type seen both in athletes and the general population) are ideal indications for low-invasive internal fixation with a compression screw. Specific knowledge of the surgical anatomy as well as appropriate training to get the necessary skills are prerequisites for the high union rate and low complication rate that can be expected from this method.

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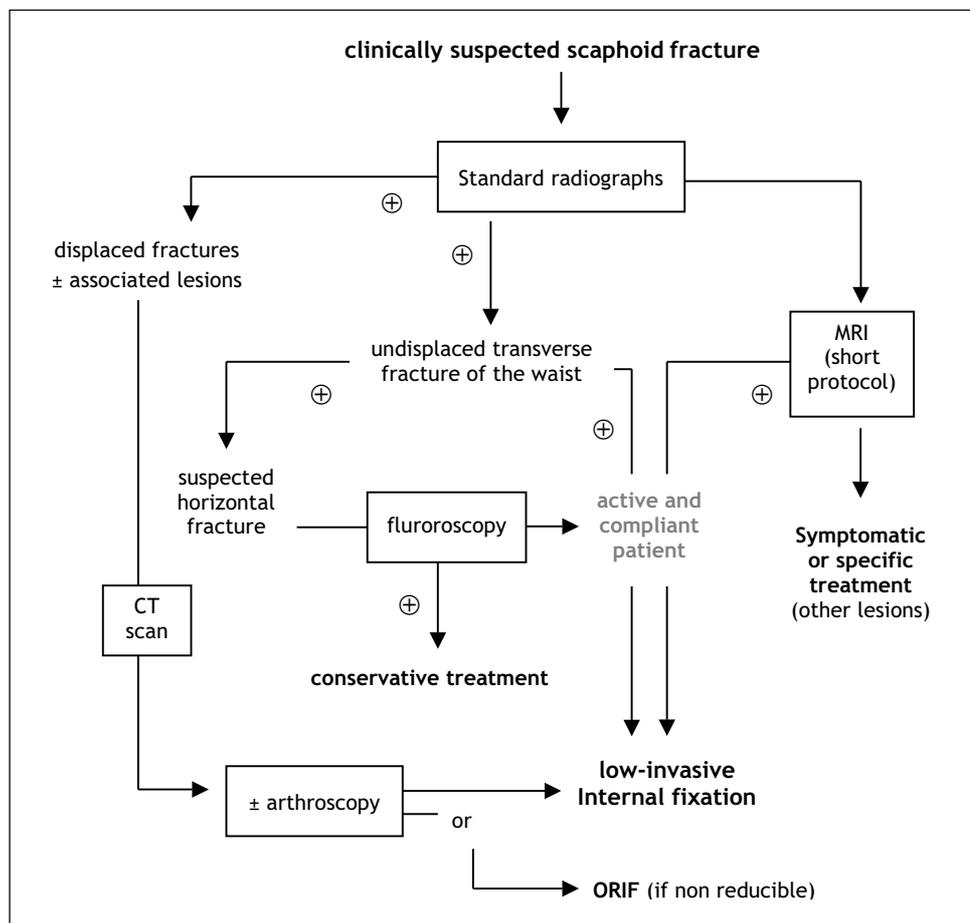


Figure 6: Diagnosis and treatment guidelines for clinically suspected acute scaphoid fractures.

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