The Dilemmas of a Scaphoid Fracture: A Difficult Diagnosis for Primary Care Physicians

Ryan Nishihara, MD

Scaphoid fractures account for 2% to 7% of all orthopedic fractures,[1] are the most common of all carpal bone fractures, and are the most commonly undiagnosed fracture.[2–9] Scaphoid fractures have produced great confusion in the medical community regarding clinical diagnosis, radiographic evaluation, and therapeutic management. Misdiagnosis and improper treatment can result in potentially devastating complications such as delayed fracture union, pseudarthrosis, avascular necrosis, and wrist instability, all of which can lead to deformity and osteoarthritis.[10] Emergency department physicians as well as orthopedic surgeons are accustomed to dealing with scaphoid fractures. However, pediatricians, internists, and family practitioners, who are usually the first physicians to encounter a patient with a painful wrist, may not feel comfortable diagnosing these patients because of their unfamiliarity with scaphoid fractures.

The purpose of this article is to relieve the uneasiness that primary care physicians may have dealing with scaphoid fractures. Anatomy, mechanism of injury, skeletal maturity, signs and symptoms, diagnosis, treatment, and outcomes are discussed.

ANATOMY

The scaphoid bone is the largest of the proximal carpal bones and articulates with the distal radius proximally, the lunate medially, and the trapezium, capitate, and trapezoid distally (**Figure 1**).[11] The scaphoid has an unusual "twisted" shape and orientation;[12] in turn, views of the scaphoid from the sagittal and coronal planes appear different in terms of its three-dimensional anatomy. The scaphoid is positioned in the carpus that bridges the proximal and distal rows,[2,6,13] which adds to wrist mobility and stability but makes the scaphoid vulnerable to trauma. The scaphoid is suspended within the wrist and covered almost completely by cartilage.[14] This milieu is ideal for the complicated functions of the wrist but is suboptimal for fracture healing.[12] Similar to the healing process in other intracapsular fractures, the scaphoid unites by primary bone healing, with direct formation of bone across the fracture and without external callous formation.[12]

The scaphoid receives its blood supply from the radial artery and branches of the anterior interosseous artery (**Figure 2**). Intraosseous and extraosseous pathways distribute the vascular supply throughout the scaphoid bone. However, the proximal one third of the bone experiences poor vascular circulation[15] and principally relies on retrograde blood flow.[12] The dorsal and volar branches of the anterior interosseous artery anastomosing with dorsal and volar branches of the radial artery provide collateral circulation to the scaphoid bone.[16] Surrounding synovial fluid provides vascular supply to the articular cartilage.

MECHANISM OF INJURY AND SKELETAL MATURITY

The same wrist trauma that can produce a Colles' fracture in an elderly patient may result in a scaphoid fracture in an adolescent or young adult, an epiphyseal displacement in a school-aged child (age 5 to 11 years), and a greenstick fracture of the radius in a toddler (age 1 to 5 years).[17] The effect of that trauma on the wrist is related to both the mechanism of injury and the skeletal maturity of the patient.[17]

Mechanism of Injury

The mechanism of injury that results in a scaphoid fracture may vary. The majority of scaphoid fractures (73%) are the result of wrist extension injuries received after a fall on the out-stretched hand. With this mechanism of injury, a force is applied to the palmar aspect of

Dr. Nishihara is Assistant Clinical Professor, Department of Pediatrics, University of Nevada School of Medicine, Las Vegas, NV, and a Fellow in Adolescent Medicine, Department of Pediatrics, University of California, Los Angeles, Los Angeles, CA.

Permission to electronically reproduce this figure not granted by copyright holder.

Figure 1. Illustration of the right wrist demonstrating the location of the scaphoid bone in relation to the forearm and metacarpals. Reprinted with permission from the *Atlas of Human Anatomy,* illustrated by Frank H. Netter, MD. Copyright 1989. Novartis. All rights reserved.

the wrist while it is dorsiflexed (**Figure 3**). The fracture usually occurs at the distal third of the bone.[18,19] According to Hopkins,[20] a fall on an extended hand, usually with radial flexion, produces a force that is transmitted through the third metacarpal to the capitate, which compresses the narrow portion of the scaphoid against the radius.

Scaphoid bone injuries as a result of the mechanism of injury responsible for the metacarpal boxer's fracture have also been reported (**Figure 4**).[19–21] Leslie and Dickson[19] stated that a closed fist mechanism of injury (ie, a "direct blow") accounted for 2.6% of injuries to the carpal scaphoid. Hopkins[20] found that one out of 23 cases of scaphoid fractures was the result of a boxing injury. In a study conducted by Horii et al,[21] 18 out of 125 patients with scaphoid fractures sustained the injury from a punching mechanism. Horii et al[21] noted that when punching, the wrist is fixed in a neutral to slightly palmar flexed position (Figure 4). Therefore, the mechanism of the fracture is a result of the concentration of external force on the second metacarpus. The force is dispersed to the trapezium and trapezoid producing a shearing stress at the waist of the scaphoid.

Skeletal Maturity

Ossification of the scaphoid begins between age 5 to 6 years and is complete between age 13 to 15 years.[14,22] Before ossification is complete, the scaphoid is almost entirely cartilaginous. Throughout this ossification period, fractures of the scaphoid are less common. This infrequency can possibly be explained by the protection provided by a thick peripheral cartilage that envelops the ossific nucleus.[14,23] The cartilaginous covering of the scaphoid bone provides increased pliability and a cushioning effect, decreasing the susceptibility to fracture. Therefore, a greater force is required to fracture an ossifying scaphoid compared with a skeletally mature scaphoid.[23] In addition to skeletal maturation, the changing patterns of physical activity from childhood to adolescence may explain the relative rarity of scaphoid fractures in children.[24]

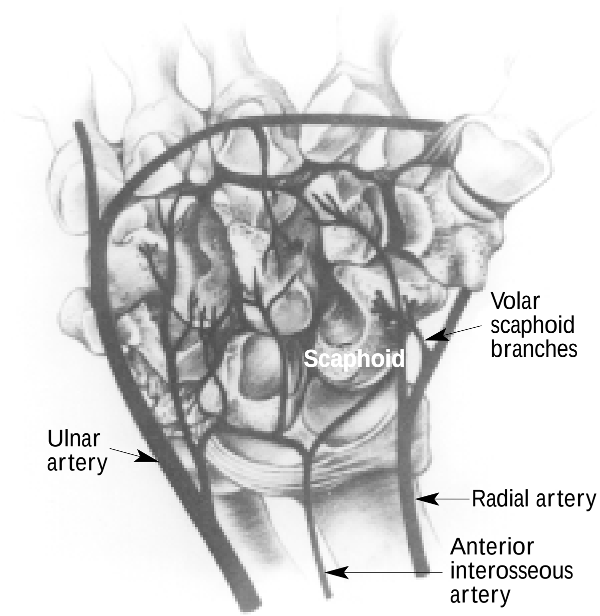


Figure 2. Illustration of the volar external blood supply to the scaphoid. Adapted with permission from Gelberman RH, Menon J: The vascularity of the scaphoid bone. *J Hand Surg [Am]* 1980;5:508.

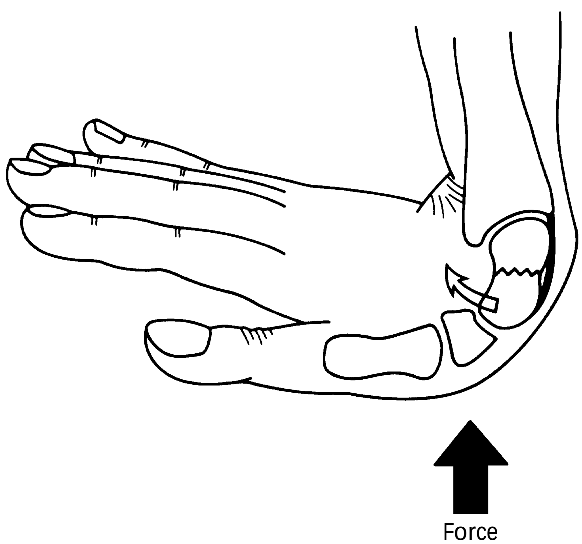


Figure 3. Illustration of the wrist extension mechanism, in which an external (bending) force is transmitted through the distal pole of the scaphoid (white arrow) and produces fracture. Adapted with permission from Horii E, Nakamura R, Watanabe K, Tsunoda K: Scaphoid fracture as a "puncher's fracture." *J Orthop Trauma* 1994;8:109.

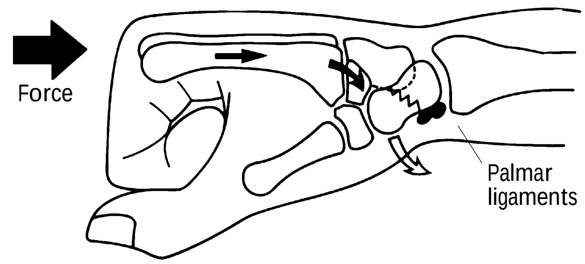


Figure 4. Illustration of the neutral or slight palmar flexed position, in which the external force is transmitted through the second metacarpal, disperses to the trapezoid and trapezium (black arrows), and results in flexion at the distal pole of the scaphoid (white arrow). The palmar ligaments, which hold the proximal pole of the scaphoid, act as the fulcrum. Adapted with permission from Horii E, Nakamura R, Watanabe K, Tsunoda K: Scaphoid fracture as a "puncher's fracture." *J Orthop Trauma* 1994;8:109.

Skeletally immature patients. In skeletally immature patients, scaphoid fractures account for less than 1% of all fractures,[18,25] less than 1% of fractures occurring in the upper limb,[9,18] and 93% of all carpal fractures.[8,9,18] In patients younger than age 15 years, the incidence of fractures of the distal radius is higher than that for scaphoid fractures presumably because of the relative weakness of the distal radial physis.[14,15,23,24,26] Stanciu and Dumont[24] note that scaphoid fractures in skeletally immature patients can easily be missed, especially when the fracture is associated with a more evident distal forearm injury. Because the number of misdiagnosed scaphoid fractures is indeterminable, the exact incidence of scaphoid fractures in skeletally immature patients can only be speculative.[24] Although the majority of literature reports fractures of the scaphoid in older children (ie, age 15 years), studies have demonstrated scaphoid fractures in patients younger than age 9 years.[15,18]

Skeletally immature versus adult patients. Christodoulou and Colton[18] have found two principal differences between the scaphoid fractures of adults and children. First, in patients younger than age 15 years, most scaphoid fractures occur at the distal pole, often with an avulsion injury.[24,26] In adults, however, more than 50% of scaphoid fractures occur through the waist or proximal one third of the scaphoid.[9,18,27] Second, incomplete or single cortex fractures are not uncommon in children, whereas displaced fractures are more common in the adult population. The difference may be related to the low-energy injuries typical in child patients (eg, a fall onto an outstretched hand) compared

(continued on page 29)

(from page 26)

with the more high-energy trauma demonstrated in adult patients (eg, a fall onto an outstretched hand from a relatively greater height, sports activities).[18]

SIGNS AND SYMPTOMS

The diagnosis of a scaphoid fracture requires a thorough history and physical examination, proper diagnostic evaluation, and a high degree of clinical suspicion. The clinical presentation of a scaphoid fracture may vary. The injuries to the scaphoid can be either acute or superimposed onto a preexisting injury.[28] Symptoms can resemble those indicative of a simple sprain or a severely injured wrist and/or hand. Usually, no wrist deformity is noted other than swelling on the radial side.[29] Many cases of scaphoid fractures remain undiagnosed after the initial injury because early symptoms can be minimal; in turn, the condition is considered minor.

Tenderness in the anatomic snuff box, which is located between the extensor pollicis longus and extensor pollicis brevis tendons (**Figure 5**), is the clinical sine qua non of scaphoid fracture.[7,29–32] However, a fracture at the radial styloid, distal radius, trapezium, or the first and second metacarpals, in addition to many sprains can all produce pain at the anatomic snuff box. Additional clinical signs to consider when attempting to diagnosis a scaphoid fracture are listed in **Table 1**.

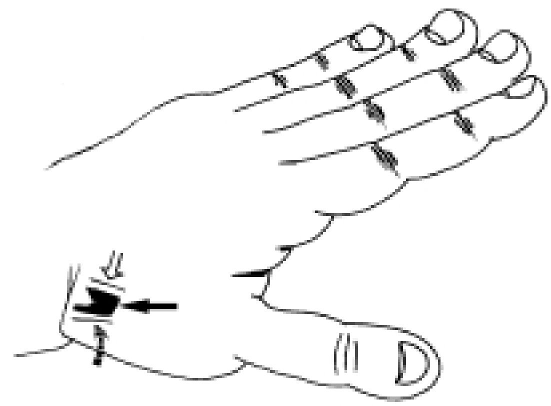


Figure 5. Illustration of the anatomic snuff box. The scaphoid and trapezium bones form the floor (black arrow); the extensor pollicis brevis serves as the medial border (white arrow); and the extensor pollicis longus is the lateral border (striped arrow) of the snuff box.

DIAGNOSIS

Various radiologic modalities can be used to diagnose a scaphoid fracture. These diagnostic methods include plain radiography, carpal box radiography, magnetic resonance imaging (MRI), bone scintigraphy, color flow Doppler ultrasonography,[33] intrasound vibration,[34,35] computed tomography, complex motion tomography,[36] flexion-extension tomography, and wrist arthrography. The use of various radiologic evaluations in the diagnosis of a scaphoid fracture indicates the complexity of the diagnosis.[37] Primary care physicians should check with the hospital radiologist to be aware of which modality is used in the diagnosis of a scaphoid fracture within the particular medical center.

Plain Radiography

With modern radiographic techniques, some authors claim that fractures of the scaphoid are typically visible on primary radiographs.[19,38] However, scaphoid fractures are often difficult to visualize on radiographs, and negative radiography does not always indicate the absence of a scaphoid fracture. The identification of a scaphoid fracture on an initial radiograph can be tremendously difficult. According to Waeckerle,[10] an initial radiograph has a false-negative range of 2% to 16%. Tiel-van Buul et al[2] attribute the diagnostic difficulty to the unique shape and position of the scaphoid in the carpus. In both children and adults, a second radiograph performed 2 weeks after the initial radiograph still does not have a 100% sensitivity but may detect a number of fractures missed initially.[39] Occult fractures that were not visible on initial radiograph may become evident after a period of time when bone resorption makes the fracture line more apparent[28] or when new bone formation is evident. Cases of fractures becoming visible between 3 to 6 weeks after injury have been reported.[3]

Technique. The radiograph of any fracture requires an anterior-posterior and lateral view to determine alignment, angulation, and displacement of the fracture and to exclude additional lesions such as carpal instability.[12,40,41] However, the architecture of the scaphoid bone requires a more complicated series, which includes at least four different radiographic views: an anterior-posterior view, a lateral view, a periapical view with the wrist pronated 45 degrees, and a periapical view with the wrist supinated 45 degrees (**Figure 6**). An oblique view of the wrist in ulnar deviation (ie, navicular view) is also helpful to expose the entire scaphoid without overlap of other bones.[42–44]

Stripe sign. A positive navicular fat pad, termed *stripe sign*, is a useful radiographic sign of a scaphoid fracture. The fat stripe of the scaphoid is a small triangular collection of fat located between the radial collateral ligament and the synovial tendon sheaths of the abductor pollicis longus and the extensor pollicis

Table 1. Various Clinical Signs in the Diagnosis of Scaphoid Fracture

Study	Clinical procedure/description	Sensitivity, %	Specificity, %
Powell et al	Pronation of the affected wrist followed by ulnar deviation	100	66
Esberger	Longitudinal pressure is placed down the thumb to compress the scaphoid (scaphoid compression test)	70.5	21.8
Verdan	Pain on the radial wrist with resisted pronation	68	73
Zarnett et al	Tenderness in the anatomic snuff box	65	86
Verdan	Pain on the radial wrist with resisted supination	63	82
Barton	Swelling in the anatomic snuff box	48	60
Barton	Discoloration of the anatomic snuff box	19	28
Study	**Additional clinical signs of scaphoid fracture**		
Cole et al	Axial compression along the index and middle fingers		
Soto-Hall	Percussion on the tip of the abducted thumb or distal end of the second metacarpal		
Soto-Hall	Forced dorsiflexion of the hand		
Hopkins	Forced ulnar flexion of the wrist		
Hopkins	Percussion on the third metacarpal		
Jacobsen et al	Axial loading through the first metacarpal and the combination of full pronation and ulnar deviation of the hand		

Powell JM, Lloyd GJ, Rintoul RF: New clinical test for fracture of the scaphoid. *Can J Surg* 1988;31:237–238.

Esberger DA: What value the scaphoid compression test. *J Hand Surg [Br]* 1994;19:748–749.

Verdan C: Fractures of the scaphoid. *Surg Clin North Am* 1960;40:461–464.

Zarnett R, Martin C, Barrington TW, et al: The natural history of suspected scaphoid fractures. *Can J Surg* 1991;34:334–337.

Barton NJ: Twenty questions about scaphoid fractures. *J Han Surg [Br]* 1992;17:289–310.

Cole WH, Williamson GA: Fractures of the carpal navicular bone. *Minnesota Medicine* 1935;18:81–83.

Soto-Hall R: The conservative and operative treatment of fractures of the carpal scaphoid (navicular). *J Bone Joint Surg Am* 1941;23:841–850.

Hopkins FS: Fractures of the scaphoid in athletes. *N Engl J Med* 1933;209:687–690.

Jacobsen S, Hassani G, Hansen D, Christensen O: Suspected scaphoid fractures: can we avoid overkill? *Acta Orthop Belg* 1995;61:74–78.

brevis (**Figure 7**).[25,45] The fat stripe is normally seen on anterior-posterior and anterior oblique views as a thin radiolucent line paralleling the lateral surface of the scaphoid (**Figure 8**).[25,32,45] Hemarthrosis and/or swelling can develop around the bone within 12 to 72 hours after a fracture has been sustained to the scaphoid. This swelling can obliterate or radially displace the fat stripe (**Figure 9**).[5,25,45] An obliterated, or positive, navicular fat stripe creates a high suspicion of scaphoid fracture and would dictate acute fracture treatment.[32] The fat stripe usually cannot be visualized in children younger than age 12 years. Absence of a navicular fat sign has also been noted in a small percentage of the adult population.[25] Other fractures that may be associated with a positive navicular fat stripe include the radial styloid, trapezium, and the base of the first metacarpal bone.[25]

Carpal Box Radiography

Carpal box radiography (**Figure 10**) was developed to elongate and magnify the carpus, which reduces the overlap and creates a clearer image of the various carpal bones (**Figure 11**). This diagnositic modality allows improved visualization of the scaphoid bone with less bone-to-bone overlap when compared with plain scaphoid radiography.

Magnetic Resonance Imaging

MRI is well established in the investigation of musculoskeletal trauma and also has the potential to demonstrate ligamentous and soft tissue injury.[46] MRI has proven especially beneficial in the diagnosis of scaphoid fractures. Gaebler et al[3] demonstrated a 100% sensitivity in the diagnosis of scaphoid fracture using MRI. A bandlike edema that reaches from one

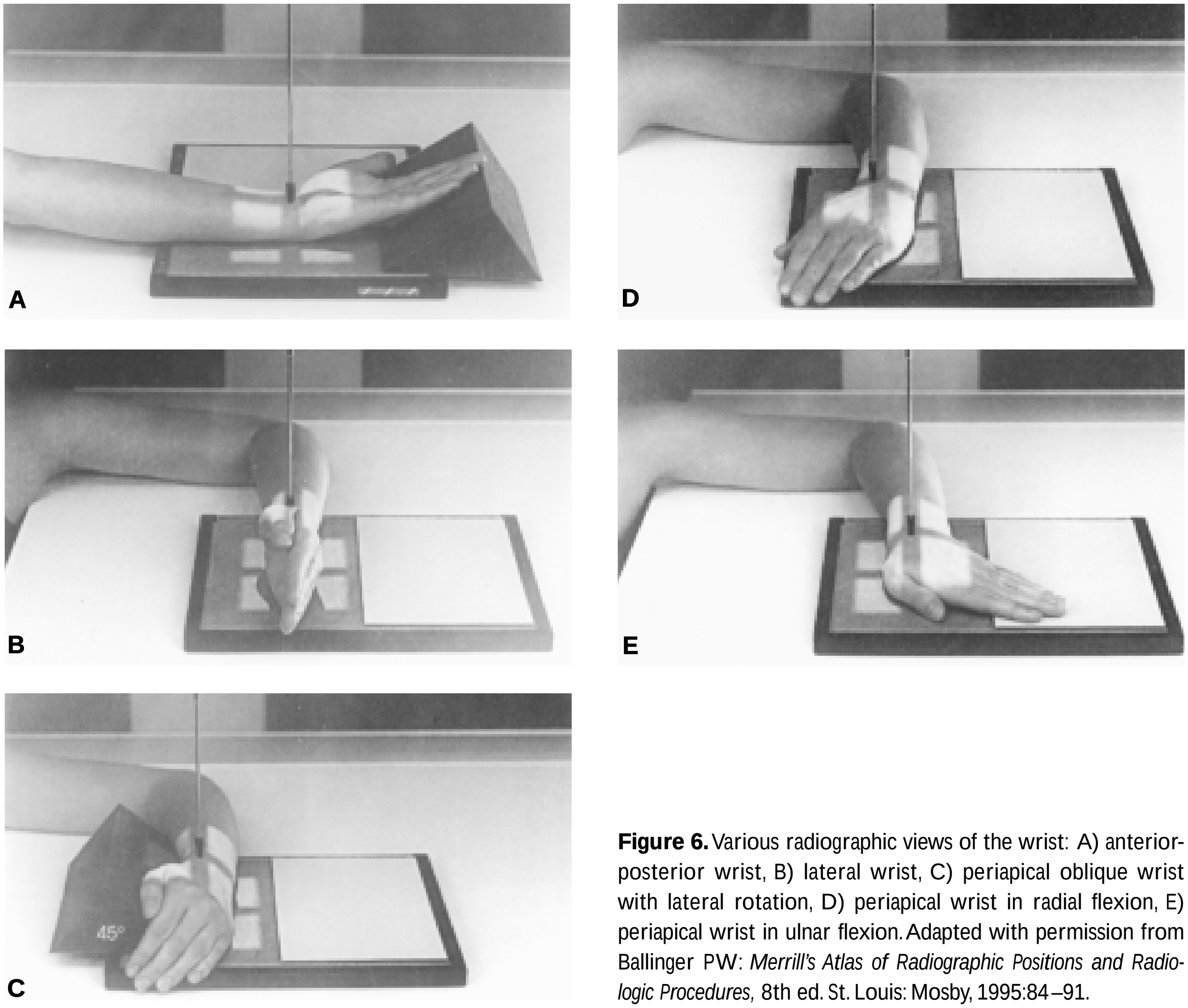


Figure 6. Various radiographic views of the wrist: A) anterior-posterior wrist, B) lateral wrist, C) periapical oblique wrist with lateral rotation, D) periapical wrist in radial flexion, E) periapical wrist in ulnar flexion. Adapted with permission from Ballinger PW: *Merrill's Atlas of Radiographic Positions and Radiologic Procedures,* 8th ed. St. Louis: Mosby, 1995:84–91.

corticalis to the other corticalis is the typical feature of a scaphoid fracture.[3] The immediacy of diagnosis is the main advantage provided by MRI.

Without MRI, definitive diagnosis can require between 10 days to 4 weeks of repeated clinical and radiographic examinations in addition to cast immobilization.[3] MRI can also better visualize avascular necrosis, ligamentous injury, and carpal instability.[46] However, MRI is expensive and many small hospitals do not have MRI machines. The decision to order an MRI in the evaluation of persistent wrist pain should usually be left to an orthopedic specialist.[46]

Bone Scintigraphy

Bone scintigraphy is a sensitive, noninvasive technique used in combination with physical examination and additional imaging studies in the diagnosis of bone disease.[7,47] Bone scintigraphy can detect areas of increased bone turnover, as long as an intact blood supply is able to deliver the radionuclide agent.[7]

Bone scintigraphy can be used to diagnose occult scaphoid fractures by demonstrating increased blood flow, blood pooling, and delayed static image uptake in the scaphoid bone.[7] Vrettos et al[47] found bone scintigraphy to have a positive predictive value of 93% and a negative predictive value of 100% in diagnosing scaphoid fracture. Bone scintigraphy can also be used to detect other areas of occult trauma that may have occurred in the wrist. However, bone scintigraphy carries several disadvantages. The process cannot be performed until 72 hours after the trauma.[6] According to Brown,[5] bone scintigraphy must be delayed for a short

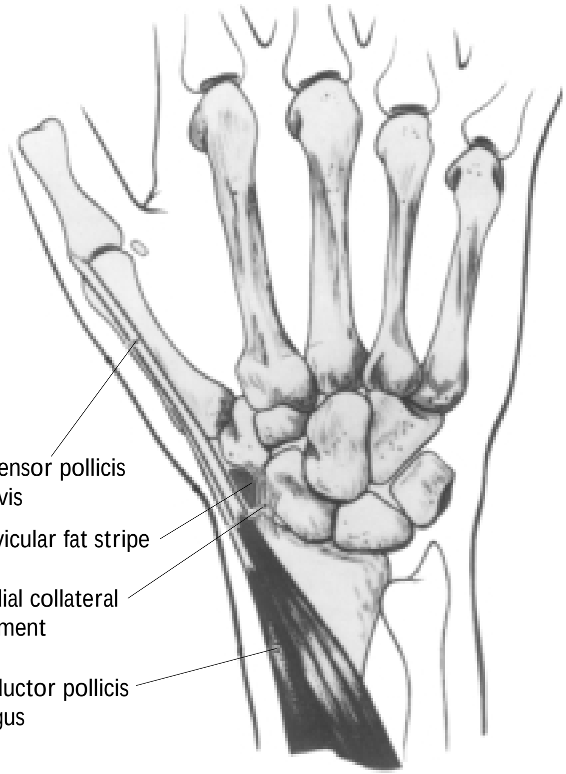


Figure 7. Illustration of the navicular (scaphoid) fat stripe, located between the combined tendon sheaths of the abductor pollicis longus and extensor pollicis brevis and the lateral surface of the scaphoid. Adapted with permission from Terry DW, Ramin JE: The navicular fat stripe: a useful roentgen feature for evaluating wrist trauma. *Am J Roentgenol Ther Nucl Med* 1975;124:25–27.

period of time in order to reduce positive readings secondary to traumatic synovitis. Vrettos et al[47] stated that a 24-hour time interval between the initial injury and scintigraphy is adequate. Additional disadvantages to bone scintigraphy include the application's unavailability to small hospitals[6] and the relatively large amount of radiation used.[6] Bone scintigraphy may be inappropriate for use in women of child-bearing age[48] and may also produce false positives in elderly patients with arthritis, children with open epiphysis, and patients with acute tenosynovitis.[48]

TREATMENT AND OUTCOMES

Successful treatment of a scaphoid fracture is dependent on early recognition and complete immobilization of the bony fragments. However, management of scaphoid fractures is controversial. Currently, any clinical suspicion of an occult scaphoid fracture (ie, new or superimposed onto an old injury[28]) requires cast immobilization, even if a fracture is not confirmed by the scaphoid series radiographs.[3,28,29,49–51]

The suggested duration of immobilization and consecutive radiography ranges between 10 to 14 days; however, there are no firm rules concerning the period of immobilization.[19] As noted previously, visualization of a scaphoid fracture is sometimes difficult because the fracture line may not be present until 1 to 3 weeks after the injury. Thus, if a patient with absent radiologic findings continues to complain of wrist pain in the snuff box area, persistent immobilization may be required for an additional 2 weeks. Fracture healing is demonstrated clinically by the disappearance of anatomic snuffbox tenderness and the development of trabeculae as seen on radiograph.[32]

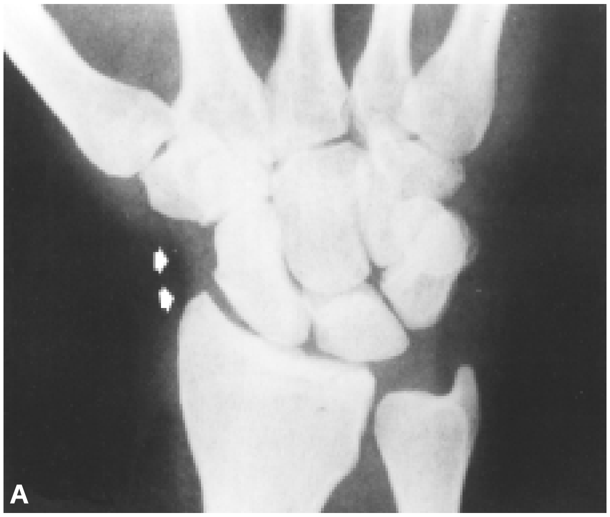
Immobilization

Immobilization is the primary objective in the treatment of scaphoid fractures. Immobilization can be accomplished with a thumb spica splint or cast (**Figure 12**), which can also be used for immobilizing any fracture or dislocation of the thumb unit (ie, trapezium, metacarpal, or proximal phalanx).[50] A thumb spica splint provides adequate immobilization and accommodates any swelling that might occur. In general, the literature is controversial regarding the position of the wrist and thumb during the immobilization period as well as whether the cast should be extended to or above the elbow level.[32] The thumb spica splint places the wrist in slight extension and slight radial deviation with the thumb in a grasping position. When the swelling has resolved (approximately 1 week after injury), the splint can be replaced with a circumferential cast (**Figure 13**).[52] The subsequent casting for a stable fracture includes placing the wrist slightly dorsiflexed and radial deviated with the thumb in a grasping position (included in the casting beyond the interphalangeal joint).[13] Potentially unstable fractures (eg, nondisplaced transverse fracture, oblique fracture, vertical fracture) may require a long arm-thumb spica cast for approximately 6 weeks, followed by a short arm cast.[29]

The duration of immobilization is primarily dependent on the location of fracture. Nondisplaced fractures of the distal third of the scaphoid have excellent healing potential and usually require 6 to 8 weeks of immobilization. Fractures of the middle third of the scaphoid require 6 to 12 weeks of immobilization. Specifically, fractures at the transverse, horizontal oblique, and vertical oblique take 6 to 12 weeks, 6 to 8 weeks, and 10 to 12 weeks to heal, respectively. Fractures of the proximal third of the scaphoid require

(continued on page 34)

(from page 32)



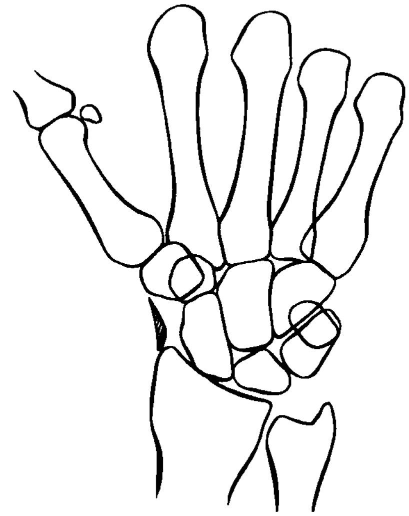


Figure 8. Radiograph and line drawing of the navicular (scaphoid) fat stripe in a normal wrist. A) The white fat stripe (arrows) is evident on the radiograph; B) the shaded area of the line drawing depicts the fat stripe. Adapted with permission from Terry DW, Ramin JE: The navicular fat stripe: a useful roentgen feature for evaluating wrist trauma. *Am J Roentgenol Ther Nucl Med* 1975;124:25–27.

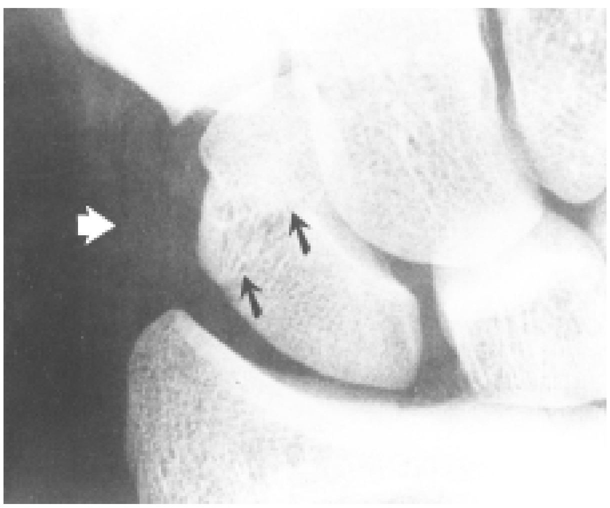


Figure 9. Radiograph displaying a positive navicular (scaphoid) fat stripe. A scaphoid fracture (black arrows) has resulted in the obliteration of the fat stripe (white arrow). Adapted with permission from Terry DW, Ramin JE: The navicular fat stripe: a useful roentgen feature for evaluating wrist trauma. *Am J Roentgenol Ther Nucl Med* 1975;124:25–27.

10 to 12 weeks of immobilization because of the poor vascular supply that reaches this region.[53] The location of the fracture also determines the duration of immobilization recommended for fracture healing in children. According to Vahvanen and Westerlund,[15] 100% of child patients with avulsed and incomplete scaphoid fractures experienced relief of symptoms and demonstrated fracture fusion on radiography after 3 to 4 weeks of immobilization. Transverse fractures required 4 to 8 weeks of immobilization.[15]

Delayed Union and Nonunion of Scaphoid Fracture

A displaced scaphoid fracture exists if there is 1 mm of displacement or 15 degrees of angulation.[12] Any fracture with an offset greater than 1 mm is usually associated with malrotation and poor fragment healing.[32] A displaced fracture is considered unstable with a high incidence of nonunion.[12] A fracture nonunion is defined as absence of evidence of healing at 6 months after injury.[2] A delayed union of fracture is considered to be present if there is no evidence of healing after 3 months.[29] Despite adequate nonoperative treatment, scaphoid fracture nonunion occurs at a rate of 3% to 10%.[39] According to Leslie and Dickson,[19] 11 cases of nonunion were found in 222 fractures, an incidence of 5%. The rate of nonunion in patients who do not receive treatment for scaphoid fracture is markedly higher.[39] Persistent nonunion generates arthritic changes at the distal pole and radial styloid articulation, which progress to the scaphocapitate joint. Initially these changes are asymptomatic, however, clinical symptoms progress over time,[12] eventually resulting in osteoarthritis.

As previously mentioned, the principal difference between scaphoid fractures in the skeletally immature patient and the adult patient is site of fracture. In children, the distal one third of the scaphoid is most

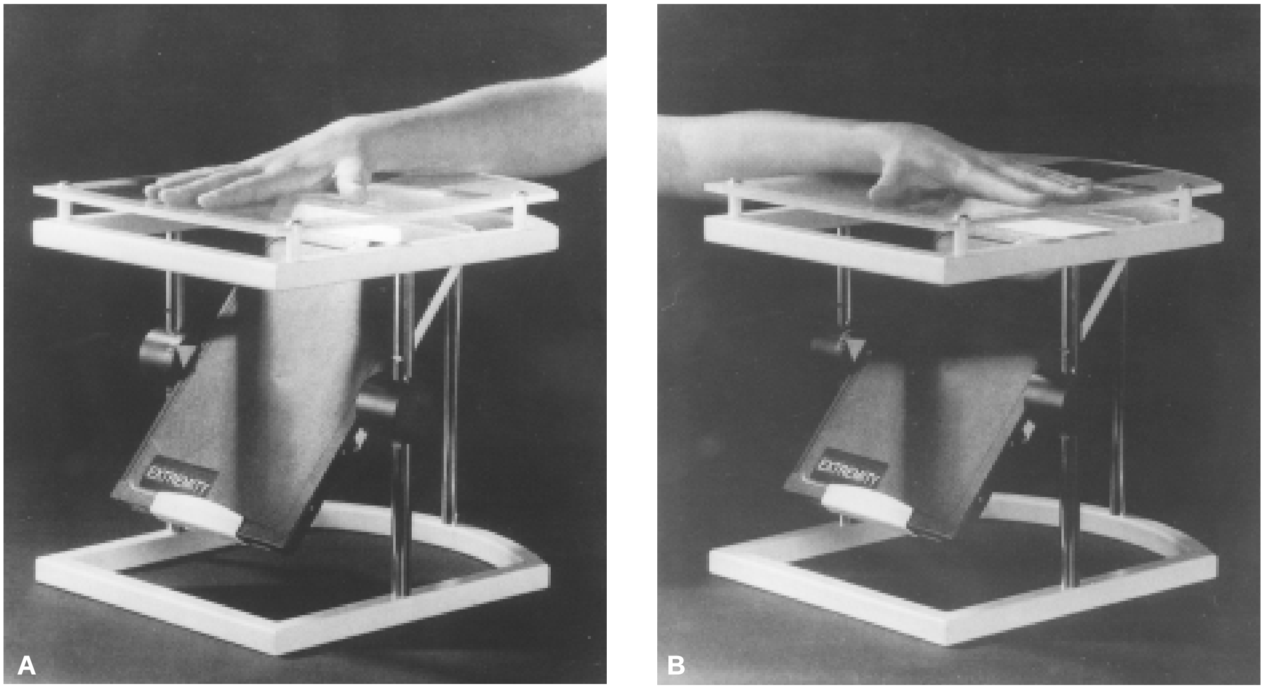


Figure 10. Photograph of the carpal box radiograph apparatus with the hand placed on top in the A) longitudinal and B) transverse positions. Adapted with permission from Rookler W, Tiel-van Buul MM, Ritt MJ, et al: Experimental evaluation of scaphoid x-series, carpal box radiographs, planar tomography, computed tomography, and magnetic resonance imaging in the diagnosis of scaphoid fracture. *J Trauma* 1997;42:247–253.

Figure 11. Carpal box radiographs of a hand in the A) longitudinal and B) transverse positions. Adapted with permission from Rookler L, Tiel-van Buul MM, Bossuyt PP, et al: The value of additional carpal box radiographs in suspected scaphoid fracture. *Invest Radiol* 1997;32:151.

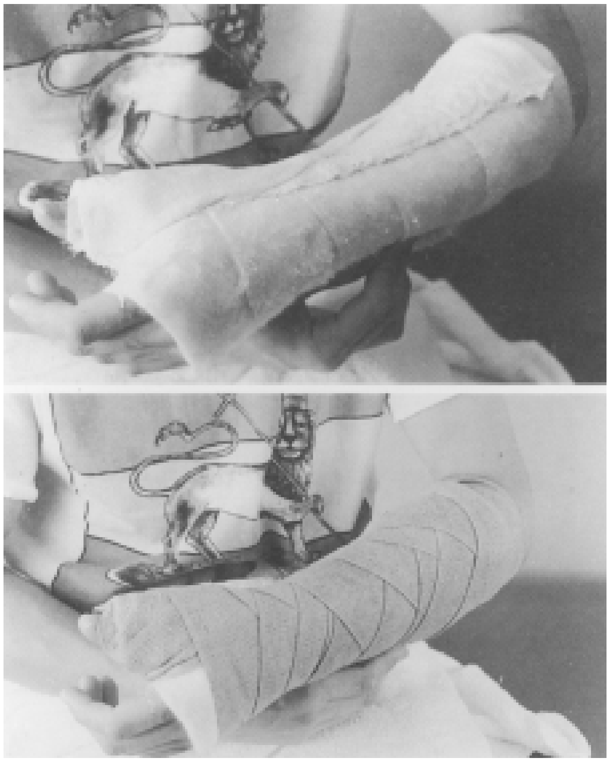


Figure 12. Photographs of a noncircumferential thumb spica/volar forearm splint used for initial immobilization of a scaphoid fracture. Adapted with permission from Garrick JG, Webb DR: Hand and wrist injuries—a scaphoid fracture. In *Sports Injuries: Diagnosis and Management,* 2nd ed. Philadelphia: WB Saunders, 1999:181.

Figure 13. Photograph of a circumferential cast, which is placed after swelling resolves and provides sufficient immobilization for most nondisplaced fractures of the distal and middle third of the scaphoid. Adapted with permission from Garrick JG, Webb DR: Hand and wrist injuries—a scaphoid fracture. In *Sports Injuries: Diagnosis and Management,* 2nd ed. Philadelphia: WB Saunders, 1999:181.

Table 2. Indications for Internal Fixation of Scaphoid Fracture

Absolute indications
Displaced scaphoid fracture
Scaphoid fracture nonunion
Scaphoid fracture associated with perilunate injury*
Relative indications
Delayed presentation
Proximal third scaphoid fracture
Unstable scaphoid fracture configuration
Scaphoid malunion

*A high-energy injury with significant bone and soft tissue damage.

frequently fractured, compared with the middle one third of the scaphoid, which is most often involved in adult patients. Fractures involving the proximal and middle one third of the scaphoid have a high risk of delayed union, therefore fracture nonunion, a potential problem in adults, is a relatively rare outcome in children.[9,18]

Onset of treatment is a determining factor in the potential development of fracture nonunion. Frequency of fracture nonunion is 88% in patients who present with scaphoid fractures more than 8 weeks after injury[2] compared with 5% to 12% in patients who acutely present and receive adequate treatment.[19] Currently, internal fixation, open reduction, and bone grafting are the standard techniques employed in the treatment of scaphoid nonunions.[39,54] Electric stimulation with continued cast protection is another option for delayed union; however, little evidence supports this approach.[29] Nonsurgical treatment of a scaphoid nonunion is a disservice to a patient because only a few of these fractures are stable and nondisplaced.[29]

Internal fixation. Internal fixation of scaphoid fractures is sometimes indicated in certain acute cases and in chronic nonunion cases.[12,55] Unstable scaphoid fractures (ie, displaced or angulated fractures) and severely comminuted scaphoid fractures, which are typically associated with extensive carpal disruption,[51] frequently require open reduction and internal fixation. Absolute and relative indications for internal fixation of scaphoid fractures are included in **Table 2**.[12] Internal fixation can be accomplished with various devices including the Herbert screw, Kirschner wire, staple fixation, and Ender's compression blade system.[39] Fractures with median nerve deficit should be treated with early exploration

(continued on page 39)

(from page 36)

and decompression.[51] Postoperative complications associated with internal fixation include infection, painful scars, and reflex sympathetic dystrophy.[56]

Orthopedic Reconstruction

The treatment of scaphoid fracture is a difficult challenge for orthopedic surgeons. The scaphoid bone does not have a growth plate, and carpal bone maturity is achieved early in life. Therefore, there is no potential to remodel any substantial degree of malunion in patients older than age 10 years.[24]

Rehabilitation

Rehabilitation after cast removal involves assisted wrist and thumb motion. Heat and ultrasound therapy can also be used to soften joint capsule contractures. A supportive stasis thumb spica splint can be used once the cast or internal hardware devices have been removed.[56]

Outcomes

The prognosis for management of an acute scaphoid fracture is dependent on two important factors: 1) fracture stability, and 2) anatomic location of the fracture.[32] The rapidity of scaphoid fracture healing is dependent primarily on the degree of circulatory damage as well as the displacement and instability of the fracture.[13] Although many scaphoid fractures heal completely, patients may present with complications such as avascular necrosis, fracture nonunion, carpal instability, and / or carpal osteoarthritis.

Avascular necrosis. Although scaphoid fractures account for a small percentage of all fractures, scaphoid fracture is second only to the femoral head in incidence of post-traumatic avascular necrosis.[16] Avascular necrosis occurs in 3% to 40% of all scaphoid fractures.[2] Avascular necrosis results in a decreased rate of fracture union with resultant joint instability and possible development of osteoarthritis. Fractures of the proximal and middle one third of the scaphoid are at increased risk for delayed healing and avascular necrosis caused by poor vascular supply.

SUMMARY

The clinical and radiographic diagnosis and treatment of a scaphoid fracture are extremely complex. Family practitioners, pediatricians, and internists are usually the first evaluators of a patient who presents with a scaphoid injury. Although approximately 90% to 95% of acute fractures of the scaphoid heal with proper immobilization, the devastating effect of improper clinical assessment, diagnostic evaluation, and therapeutic management may result in a nonunion of the fracture causing great disability to the affected wrist. Patients with potential scaphoid fractures should be treated cautiously and judiciously. Follow-up with an orthopedic surgeon is also suggested. **HP**

REFERENCES

1. Bacorn RW, Kurtzke JF: Colles fracture. *J Bone Joint Surg [Br]* 1953;35:643.
2. Tiel-van Buul MM, Roolker W, Broekhuizen AH, Van Beek EJ: The diagnostic management of suspected scaphoid fracture. *Injury* 1997;28:1–8.
3. Gaebler C, Kukla C, Breitenseher M, et al: Magnetic resonance imaging of occult scaphoid fractures. *J Trauma* 1996;41:73–76.
4. Larsen CF, Brondum V, Skov O: Epidemiology of scaphoid fractures in Odense, Denmark. *Acta Orthop Scand* 1992;63:216–218.
5. Brown JN: The suspected scaphoid fracture and isotope bone imaging. *Injury* 1995;26:479–482.
6. Rookler L, Tiel-van Buul MM, Bossuyt PP, et al: The value of additional carpal box radiographs in suspected scaphoid fracture. *Invest Radiol* 1997;32:149–153.
7. Vande Streek P, Carretta RF, Weiland FL, Shelton DK: Upper extremity radionuclide bone imaging: the wrist and hand. *Semin Nucl Med* 1998;28:14–24.
8. Munk B, Frokjaer J, Larsen CF, et al: Diagnosis of scaphoid fractures: a prospective multicenter study of 1052 patients with 160 fractures. *Acta Orthop Scand* 1995;66:359–360.
9. Mintzer CM, Waters PM: Surgical treatment of pediatric scaphoid fracture nonunions. *J Pediatr Orthop* 1999;19: 236–239.
10. Waeckerle JF: A prospective study identifying the sensitivity of radiographic findings and the efficacy of clinical findings in carpal navicular fractures. *Ann Emerg Med* 1987;16:733–737.
11. Netter FH: *Atlas of Human Anatomy,* 1st ed. West Caldwell, CIBA-GEIGY Corporation (Novartis), 1989:426.
12. Kozin SH: Internal fixation of scaphoid fractures. *Hand Clin* 1997;13:573–586.
13. Connolly JF: Fractures of the scaphoid. In *DePalma's The Management of Fractures and Dislocations: An Atlas*, 3rd ed. Philadelphia: WB Saunders, 1981:1059–1063.
14. Southcott R, Rosman MA: Nonunion of carpal scaphoid fractures in children. *J Bone Joint Surg [Br]* 1977;59: 20–23.
15. Vahvanen V, Westerlund M: Fracture of the carpal scaphoid in children: a clinical and roentgenological study of 108 cases. *Acta Orthop Scand* 1980;51:909–913.
16. Gelberman RH, Menon J: The vascularity of the scaphoid bone. *J Hand Surg [Am]* 1980;5:508–513.
17. Grundy M: Fractures of the carpal scaphoid in children: a series of eight cases. *Br J Surg* 1969;56:523–524.
18. Christodoulou AG, Colton CL: Scaphoid fractures in children. *J Pediatr Orthop* 1986;6:37–39.
19. Leslie IJ, Dickson RA: The fractured carpal scaphoid:

natural history and factors influencing outcome. *J Bone Joint Surg [Br]* 1981;63:225–230.
20. Hopkins FS: Fractures of the scaphoid in athletes. *N Engl J Med* 1933;209:687–690.
21. Horii E, Nakamura R, Watanabe K, Tsunoda K: Scaphoid fracture as a “puncher’s fracture.” *J Orthop Trauma* 1994; 8:107–110.
22. Stuart HC, Idell S, Caornoni J, Reed RB: Onsets, completions, and spans of ossification in the 29 bone-growth centers of the hand and wrist. *Pediatrics* 1962;29:237–249.
23. Greene MH, Hadied AM, LaMont RL: Scaphoid fractures in children. *J Hand Surg [Am]* 1984;9:536–541.
24. Stanciu C, Dumont A: Changing patterns of scaphoid fractures in adolescents. *Can J Surg* 1994;37:214–216.
25. Cook PA, Yu JS, Wiand W, et al: Suspected scaphoid fractures in skeletally immature patients: application of MRI. *J Comput Assist Tomogr* 1997;21:511–515.
26. Mussbichler H: Injuries of the carpal scaphoid in children. *Acta Radiol* 1961;56:361–369.
27. Caputo AE, Watson HK, Nissen C: Scaphoid nonunion in a child: a case report. *J Hand Surg [Am]* 1995;20:243–245.
28. Lester B: Sports injuries. In *The Acute Hand*. Stamford, CT: Appleton and Lange, 1999:364.
29. Amadio PC: Scaphoid fractures. *Orthop Clin North Am* 1992;23:7–17.
30. Powell JM, Lloyd GJ, Rintoul RF: New clinical test for fracture of the scaphoid. *Can J Surg* 1988;31:237–238.
31. Bick EM: *Classics of Orthopaedics*. Philadelphia: Lippincott, 1976:356.
32. Dee R, Hurst LC, Gruber MA, Kottmeier SA: Fractures and dislocations of the hand and wrist. In *Principles of Orthopaedic Practice*, 2nd ed. New York: McGraw-Hill, 1997:435–437.
33. Hodgkinson DW, Nicholson DA, Stewart G, et al: Scaphoid fracture: a new method of assessment. *Clin Radiol* 1993;48:398–401.
34. Knight P, Rothwell AG: Intrasound vibration in the early diagnosis of scaphoid fracture. *J Hand Surg [Am]* 1998; 23:233–235.
35. Finkenberg JG, Hoffer E, Kelly C, Zinar DM: Diagnosis of occult scaphoid fracture by intrasound vibration. *J Hand Surg [Am]* 1993;18:4–7.
36. Smith DK, Linschied RL, Amadio PC, et al: Scaphoid anatomy: evaluation with complex motion tomography. *Radiology* 1989;173:177–180.
37. Roolker W, Tiel-van Buul MM, Ritt MJ, et al: Experimental evaluation of scaphoid x-series, carpal box radiographs, planar tomography, computed tomography, and magnetic resonance imaging in the diagnosis of scaphoid fracture. *J Trauma* 1997;42:247–253.
38. Jacobsen S, Hassani G, Hansen D, Christensen O: Suspected scaphoid fractures: can we avoid overkill? *Acta Orthop Belg* 1995;61:74–78.
39. Carpentier E, Sartorius C, Roth H: Scaphoid nonunion: treatment by open reduction, bone graft, and staple fixation. *J Hand Surg [Am]* 1995;20:235–240.
40. Compson JP: The anatomy of acute scaphoid fractures: a three-dimensional analysis of patterns. *J Bone Joint Surg Br* 1998;80:218–224.
41. Lindequist S, Larsen CF: Radiography of the carpal scaphoid: an experimental investigation evaluating the use of oblique projections. *Acta Radiol [Diagn] (Stockh)* 1986;27:97–99.
42. Ganel A, Israeli A, Engel J: The early diagnosis of fractures of the carpal scaphoid bone. *Br J Sports Med* 1980;14: 210–212.
43. Daffner RH, Emmerling EW, Buterbaugh GA: Proximal and distal oblique radiography of the wrist: value in occult injuries. *J Hand Surg [Am]* 1992;17:499–503.
44. Ballinger PW: Wrist. In *Merrill’s Atlas of Radiographic Positions and Radiologic Procedures*, 8th ed. St Louis: Mosby, 1995:84–91.
45. Terry DW, Ramin JE: The navicular fat stripe: a useful roentgen feature for evaluating wrist trauma. *Am J Roentgenol Ther Nucl Med* 1975;124:25–28.
46. Thorpe AP, Murray AD, Smith FW, Ferguson J: Clinically suspected scaphoid fracture: a comparison of magnetic resonance imaging and bone scintigraphy. *Br J Radiol* 1996;69:109–113.
47. Vrettos BC, Adams BK, Knottenbelt JD, Lee A: Is there a place for radionuclide bone scintigraphy in the management of radiographic-negative scaphoid trauma? *S Afr Med J* 1996;86:540–542.
48. DaCruz DJ, Bodiwala GG, Finlay DB: The suspected fracture of the scaphoid: a rational approach to diagnosis. *Injury* 1988;19:149–152.
49. Barton NJ: Twenty questions about scaphoid fractures. *J Hand Surg [Br]* 1992;17:289–310.
50. Sandzen SC: *Atlas of Wrist and Hand Fractures*, 2nd ed. Littleton, MA: PSG Publishing Company, 1986:35.
51. Bucholz RW, Lippert FG, Wenger DR, Ezaki M: Scaphoid fracture. In *Orthopaedic Decision Making*. Philadelphia: B.C. Decker, 1984:258–261.
52. Garrick JG, Webb DR: Hand and wrist injuries. In *Sports Injuries: Diagnosis and Management*, 2nd ed. Philadelphia: WB Saunders, 1999:181.
53. Young VL, Higgs PE: The injured wrist. In *Manual of Acute Hand Injuries*. Martin DS, Collins ED, eds. St. Louis: Mosby, 1998:404–433.
54. Verdan C: Fractures of the scaphoid. *Surg Clin North Am* 1960;40:461–464.
55. Haddad FS, Goddard NJ: Acute percutaneous scaphoid fixation. *J Bone Joint Surg [Br]* 1998;80:95–99.
56. Cooney WP, Schutt AH: Rehabilitation of the wrist. In *Orthopaedic Rehabilitation*, 2nd ed. Nickel VL, Botte MJ, eds. New York: Churchill Livingstone, 1992:725.