Scaphoid fractures in the athlete

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Abstract Scaphoid fractures are a common wrist injury, especially in athletes. Clinicians should have a high index of suspicion for a scaphoid fracture in any patient complaining of radial-sided wrist pain after a fall on an outstretched hand. Advanced imaging, including CT and MRI scans, may be useful in diagnosis and classification of fracture patterns. Treatment varies based on the fracture location, stability of the fracture, and predictability of the fracture to heal. Treatment involves either non-operative management with a thumb spica cast or brace, or operative fixation with a headless compression screw, k-wires, or scaphoid-specific plates. Return to play is dependent on many variables, including sport, fracture union, and ability to play with cast.

Keywords Scaphoid fracture · Athlete

Introduction

The scaphoid is the most common carpal bone fracture in athletes and accounts for up to 70% of all carpal bone fractures [1]. Males between the ages of 20–24 are associated with a higher rate of scaphoid fracture, likely secondary to participation in extreme sports and work that involves manual labor [2]. Athletes participating in football and basketball are

especially prone to scaphoid fractures given that they experience high impact injuries to the wrist. It is estimated that 1 out of 100 athletes participating in college football will sustain a scaphoid fracture [3].

Scaphoid fractures usually result from a fall with wrist hyperextension past 95° [4]. A fall on an outstretched hand causes longitudinal loading of the scaphoid and a fracture occurs as the volar cortex fails in tension. The force extends to the dorsal cortex, which fails in compression. Axial loading from a direct blow has also been presented as a possible mechanism for scaphoid fracture [5].

Scaphoid fractures should be suspected in any athlete who presents after a fall on an outstretched hand and reports radial-sided wrist pain or anatomic snuffbox tenderness. The diagnosis of acute scaphoid fracture can be difficult and initial radiographs are commonly normal. Frequently, the patient is diagnosed with a wrist sprain and is treated without any immobilization. Other times, athletes may play through pain after an injury, which may result in a delay in diagnosis. If a scaphoid fracture is suspected, the patient should be immobilized and advanced imaging, either magnetic resonance imaging (MRI) or computed tomography (CT), should be ordered [6•]. Failure to recognize a scaphoid fracture may result in nonunion in 5–25% of cases [7–9], which may lead to a predictable progression of wrist arthritis.

Traditionally, distal pole and non-displaced scaphoid fractures have been treated conservatively with a thumb spica cast. Healing times for scaphoid fractures depend on the location of the fracture. More proximal scaphoid fractures typically require longer periods of immobilization and may have a higher incidence of nonunion. Unstable fracture patterns and those prone to nonunion should be treated with surgical fixation.

There are many techniques in the literature regarding treatment of scaphoid fractures: antegrade dorsal approach, retrograde volar approach, percutaneous, and arthroscopic assisted.

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Non-operative and operative treatments both have their distinct advantages and disadvantages. The treatment approach utilized is determined not only based on the fracture pattern but also the comfort level of the operating surgeon. When scaphoid fractures are recognized early and treated appropriately, athletes will experience excellent results with early return to play with minimal disability.

Anatomy

The wrist is comprised of eight carpal bones arranged into a proximal and distal row. The scaphoid functions as a link between these two rows. The carpal rows are connected by intrinsic ligaments and surrounded by extrinsic volar and dorsal wrist ligaments. The ability of the intercarpal and radiocarpal ligaments to stabilize the intercalated proximal carpal row depends on the integrity of the scaphoid [10]. An unstable scaphoid fracture causes the distal fragment to remain flexed due to its attachments to the trapezium and trapezoid. The proximal fracture fragment extends with the lunate secondary to the attachment of the lunate to the triquetrum, which results in humpback deformity.

Approximately 80% of the scaphoid is covered by articular cartilage, which limits the area for vascular supply and ligamentous attachments [11–13]. The majority of the blood supply to the scaphoid is from the dorsal carpal branch of the radial artery [14]. The dorsal carpal branch enters the non-articular dorsal ridge and supplies 80% of the scaphoid through retrograde blood flow. The scaphoid also receives approximately 20% of its blood supply from the superficial palmar arch, which primarily supplies the distal pole. The retrograde flow to the scaphoid makes proximal pole fractures vulnerable to osteonecrosis and nonunion [15].

Classification of fractures

There are many classifications for scaphoid fractures. Russe classified scaphoid fractures as horizontal oblique, transverse, and vertical oblique (Fig. 1) [9]. Vertical oblique fractures only account for 5% of scaphoid fractures but result in the most shear forces across the fracture site, making it the most unstable [9]. Compressive forces are seen at the fracture site in horizontal oblique fractures, whereas transverse fractures have a combination of shear and compressive forces.

Review of the literature reveals that most hand surgeons classify scaphoid fracture according to the Herbert classification (Fig. 2) [16]. Herbert classification, Type A through Type C, includes the stability of the fracture but also includes delayed unions and nonunions.

Type A fractures are acute scaphoid fractures that are stable. They are further characterized as Type A1 that occur

Fig. 1 Russe classification of scaphoid fractures. Reprinted with permission from Haisman JM, Rohde RS, Weiland AJ. Acute Fractures of the Scaphoid. An Instructional Course Lecture. The Journal of Bone and Joint Surgery. Vol 88-A. No 12. Dec 2006

through the distal pole and Type A2 that are incomplete or non-displaced fractures through the waist.

Type B scaphoid fractures are considered unstable and are divided into four types. Type B1 represents a distal oblique fracture. These fractures are unstable because of the oblique nature of the fracture and are subject to shortening at the fracture site. Type B2 represents a complete fracture of the waist of the scaphoid. These are the most common type of fracture encountered.

Proximal pole fractures make up Type B3 fractures. Proximal pole fractures may be easily missed on plain radiographs. Type B3 fractures represent a challenge to stabilize operatively because the proximal fragment may be too small to fix with a single fixed headless compression screw. Type B4 scaphoid fractures are trans-scaphoid fractures that occur in perilunate dislocations of the carpus.

Type C scaphoid fractures describe a delayed union. The patient will typically remember a remote injury. The proximal pole may appear more dense on plain X-rays suggesting either AVN or relative resorption of the adjacent bones [17•].

Clinical evaluation and radiographic imaging

An athlete who falls on an outstretched hand during a game will often report wrist pain. Patients with acute scaphoid fractures will present with pain, swelling, snuffbox tenderness, and loss of wrist range of motion. Axial compression of the thumb, which loads the scaphoid fracture, will elicit pain.

Many athletes will continue with competition after injury and may delay presentation to a healthcare provider only when symptoms persist or the season ends. When this occurs, they will typically present with complaints of persistent pain and swelling. Athletes who present with chronic injury or fracture nonunion will typically endorse continued pain, radial-sided wrist pain, loss of wrist range of motion, and inability to perform a push up.

Plain radiographs should be obtained in any patient with clinical suspicion for a scaphoid fracture. Preferred views include posteroanterior (PA), lateral, and oblique wrist films.

Fig. 2 Herbert classification of scaphoid fractures. Reprinted with permission from Haisman JM, Rohde RS, Weiland AJ. Acute Fractures of the Scaphoid. An Instructional Course Lecture. The Journal of Bone and Joint Surgery. Vol 88-A. No 12. Dec 2006

Radiographic views specific for viewing the scaphoid include scaphoid (palm flush with cassette and ulnar wrist deviation) and clenched-fist PA view.

Scaphoid fractures are not visible on initial plain radiographs in up to 25% of patients (Fig. 3) [1]. Typically patients are placed into a short arm thumb spica cast and follow-up in 10–14 days for repeat radiographs. Cast application can be problematic for an athlete trying to return to play. If a fracture is suspected and radiographs are negative, a magnetic resonance imaging (MRI) can be obtained to rule out occult fractures [6•].

Computed tomography (CT) scan is useful to characterize fracture pattern and humpback deformity, guide treatment, and assess for fracture union. When ordering a CT scan, the order should include a series performed in the longitudinal axis of the scaphoid [18]. Scaphoid fracture union often cannot be reliably determined by radiographs alone at 3 months and therefore CT scan is helpful to ensure that they fracture is healed [19] (Fig. 4).

Treatment

Early diagnosis and treatment is critical to avoid short- and long-term complications of scaphoid fractures. Scaphoid fractures that are treated within 4 weeks from injury have a significantly higher union rates than in those whose treatment begins after 4 weeks [14]. Failure to recognize a scaphoid fracture may result in humpback deformity of the scaphoid and dorsal angulation of the lunate (DISI deformity). The resulting deformity may lead to abnormal carpal motion and results in secondary arthritis. Mack et al. studied the progression of wrist arthritis in patients with scaphoid nonunion [18]. Radiographic evidence of arthritis was first seen at the radioscapoid joint in the second decade from injury. Pancarpal arthritis was evident twenty to thirty years

following injury. The authors identified that scaphoid displacement and DISI deformity accelerated the arthritic process.

Non-operative treatment

Conservative treatment of scaphoid fractures is typically reserved for non-displaced fractures and those involving the distal pole. These fractures are typically managed with cast application and immobilization. It is difficult to evaluate displacement on plain radiographs, and therefore, CT scan should be utilized to ensure that a fracture is truly non-displaced [1]. Scaphoid fractures treated non-operatively typically require 9 to 12 weeks of immobilization, although the fracture may take up to 6 months to unite [20].

Scaphoid fractures treated with cast immobilization alone unite in 88 to 95% of cases [21–23]. The duration of cast treatment also varies depending on the fracture site. Fractures of the distal pole usually heal within 6 weeks whereas fractures involving the proximal pole may require 6 months or longer of cast immobilization secondary to the retrograde blood flow of the scaphoid [14].

Treatment with a short arm versus long arm thumb spica cast remains controversial. A meta-analysis by Doornberg et al. evaluated this controversy and found no difference [24]. Analysis included four randomized controlled studies including 523 patients and found no difference in the rate of nonunion between the two groups. Long arm thumb spica cast immobilization is typically reserved for non-complaint patients and those who have continued pain in a short arm cast.

Treatment options for a non-displaced scaphoid waist fracture must be discussed with the patient. Treatment with cast immobilization is not without consequences. Prolonged periods of immobilization may result in disuse osteopenia, stiffness, and muscle atrophy. These consequences of cast immobilization may be unacceptable in an athlete and may delay return to play. Non-operative treatment also requires more

Fig. 3 **a** 17-year-old female presented to primary care physician after falling on outstretched left hand during volleyball match. Radiographs read as negative and no treatment initiated. **b** Patient return to clinic 1 month later with continued wrist pain. MRI ordered which reveals subacute proximal pole fracture. **c** Repeat radiographs in orthopedic

office reveal displaced proximal pole scaphoid fracture. **d** Internal fixation with headless compression screw. **e** CT scan at 10 weeks reveals fracture union. Patient cleared for all sporting activities following confirmation of healed fracture

frequent office visits to ensure appropriate fitting of cast, monitoring for skin breakdown, and radiographic assessment for fracture alignment [25•].

Operative treatment

Fractures resulting in decreased prognosis for healing include fracture displacement, concomitant carpal ligament instability (DISI deformity), and delayed presentation greater than 4 weeks [15]. Cooney et al. defined displacement as a gap of 1 mm seen on plain radiographs, scapholunate angle greater than 60°, or a radiolunate angle greater than 15° [26]. The authors also found that displaced fractures greater than 1 mm have a nonunion rate up to 50% if treated non-operatively. Displaced scaphoid fractures should be reduced and stabilized surgically to prevent the risk of malunion or nonunion.

Many operative techniques have been described to treat scaphoid fractures. These techniques include dorsal antegrade screw, volar retrograde screw, limited open, percutaneous, and arthroscopic assisted. Bone augments may be utilized including cancellous bone, corticocancellous to correct deformity, and vascularized bone graft. The approach used depends on the fracture pattern, deformity, chronicity of fracture, bone loss, and vascularity of the proximal pole. The goal of the procedure is an anatomic reduction with a centrally placed screw [27].

Operative fixation is recommended for proximal pole scaphoid fractures. Because of the retrograde blood flow to the scaphoid, proximal pole fractures have a higher rate of nonunion when compared to fractures of the distal pole or waist [14]. It is believed that internal fixation reduces the risk of nonunion and may decrease the possibility of proximal fragment collapse due to osteonecrosis [18].

Fig. 4 **a** A 23-year-old soccer player who fell on left wrist and sustained a non-displaced scaphoid waist fracture. **b** Internal fixation with headless compression screw. Patient returned to play 1 week after surgery with short arm thumb spica during competition. **c** CT scan at 7 weeks post op shows union across fracture

Dias et al. randomized non-operative management with a short arm thumb spica cast and surgical fixation with compression screw [23]. There were no differences between the two groups at final follow-up at 1 year. However, 10 of 44 patients in the non-operative group had delayed union at 16 weeks, which required surgery. Patients in the operative group had earlier return to wrist range of motion and grip strength beginning at 8 weeks post op.

Bond et al. studied scaphoid fractures in the military population, which is similar to the athletic population given participation in strenuous physical activities. Patients were treated with either cast immobilization or screw fixation for non-

displaced scaphoid waist fractures [25•]. Those who had surgical intervention returned to all military duties 7 weeks quicker than the non-operative group. The operative group also had radiographic evidence of union 8 weeks sooner. At a final 2-year follow-up, there was no difference in wrist range of motion or grip strength.

In addition to quicker time to union and return to work, patients may begin gentle range of motion exercises when the fracture is rigidly fixed. The fracture is also less likely to lose its alignment and requires less radiographs and office visits to confirm that alignment is unchanged. Disadvantages of operative intervention include wound complications, disruption of vascular supply to the scaphoid, injury to surrounding tendons and nerves, hardware failure requiring removal, and risks of anesthesia.

Return to play

Return to sport is dependent on many variables, including sport, treatment, fracture pattern, fracture union, and league regulations. Ideally, the athlete returns to sport when he/she achieves clinical union: pain-free range of motion that is within 10° of contralateral side with grip strength within 10% of contralateral side [28, 29]. Healing should be evaluated with CT scans at 6-week intervals and return to full play allowed when 50% bridging trabeculae seen [30, 31].

If an athlete is able to perform his/her sport and wearing a cast is allowed, he/she may return to play immediately whether the scaphoid fracture was treated operatively or non-operatively. This includes many football and soccer players who are able to compete with a cast and healing with non-operatively management has been shown in this scenario [28, 32]. Athletes that require wrist motion, as in basketball, hockey, and baseball, will be unable to return to play with a cast.

Dy et al. surveyed 37 hand surgeons involved in the care of professional athletes [33•]. In regard to scaphoid fractures, 19/37 (51.4%) allowed elite athletes to return to protected play 4 to 6 weeks after operative treatment of a non-displaced scaphoid fracture. Twelve surgeons (32.4%) allow elite athletes to return to protected play immediately. For unprotected play, 9 (24.3%) allow return after 4 to 6 weeks, 18 (48.6%) after 6 to 12 weeks, and 10 (27%) wait more than 12 weeks. The authors found that surgeons who treated athletes from more than one sport were more aggressive in recommending earlier return to play.

Conclusion

Scaphoid fractures are one of the most common wrist injuries seen in athletics. Because the wrist is a non-weightbearing joint, a patient may initially believe that his/her injury is a

wrist sprain and may continue with athletic competition, therefore presenting in a delayed manner. It is important for a clinician to maintain a high level of suspicion in any patient with snuffbox tenderness, swelling, and loss of wrist range of motion. Appropriate radiographs should be obtained and advanced imaging ordered if suspicion remains despite negative radiographs.

Understanding the anatomy of the scaphoid as well as fracture patterns allows the treating physician understand which fractures will likely heal with non-operative or operative treatment. Scaphoid fractures treated with a headless compression screw show a shorter time to union and return to work/sport. Patients are also more likely to regain their wrist range of motion and grip strength faster.

Many factors should be considered when determining non-operative versus operative management and return to play. An athlete's sport, timing in season, competitive level, and rules regarding cast wear during play need to be weighed. Each athlete should be treated individually, but in general, surgery is indicated for displaced scaphoid fractures, proximal pole fracture regardless of displacement, and fracture associated with perilunate injuries.

Compliance with ethical standards

Conflict of interest Mark J. Winston declares that he has no conflict of interest.

Andrew J. Weiland reports personal fees from Medartis and Arthrex, outside of the submitted work.

Human and animal rights and informed consent This article does not contain any studies with human or animal subjects performed by any of the authors.

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