19 Arthroscopic Management of Scaphoid Fractures and Nonunions

William B. Geissler

Introduction

The scaphoid carpal bone is the most frequently fractured bone in the carpus and accounts for nearly 70 % of all carpal fractures [1]. This fracture typically occurs in young men between the ages of 15 and 30 years and is also a common athletic injury occurring most often in contact sports [2]. It has been estimated that one in 100 college football players will sustain a fracture of the scaphoid in their career [3]. Frequently, a competitive athlete does not report his initial injury and continues to compete and eventually presents to the treating physician after the season is over with a scaphoid nonunion.

Acute nondisplaced fractures of the scaphoid have traditionally been managed with cast immobilization [4, 5]. Nondisplaced scaphoid fractures may heal in 8–12 weeks when immobilized in a short or long-arm cast [4–6]. While cast immobilization is successful in up to 85–90 % of cases, there may be significant cost to the patient with prolonged immobilization [4–6]. Prolonged immobilization may lead to muscle atrophy, joint contracture, disuse osteopenia, and financial hardship. An athlete may not be able to tolerate a lengthy course of immobilization and potentially could lose his scholarship or a worker could lose his employment.

It has been shown that the duration of cast immobilization varies dramatically according to the site of the fracture. A fracture of the scaphoid tubercle may heal within a period of 6 weeks while a fracture of the waist of the scaphoid may require 3 months or longer. Fractures of the proximal pole may take 6 months or longer to heal with a cast because of the vascularity of the scaphoid [7]. It is frequently difficult to truly identify when a fracture of the scaphoid will heal with nonoperative management by plain radiograph alone. Frequently, a CT scan may be required to thoroughly evaluate when a scaphoid is healed and treated non-operatively.

Displaced scaphoids have a reported nonunion rate of up to 50 % [2]. Factors that decrease the prognosis for healing include the amount of displacement, associated carpal instability, and delayed presentation (greater than 4–6 weeks) [1]. Traditionally, acute displaced fractures of the scaphoid, proximal pole fractures, and scaphoid nonunions are managed by open reduction and internal fixation [1, 2, 8–16]. Complications associated with open reduction and internal fixation include avascular necrosis, carpal instability, donor site pain, screw protrusion, infection, and complex regional pain syndrome [4, 17]. In one series, the biggest complication was hypertrophic scarring [2]. Multiple jigs have been designed to assist in open reduction; however, they are frequently difficult to apply and may necessitate further surgical dissection [18].

Wrist arthroscopy has revolutionized the practice of orthopedics allowing the surgeon to examine intra-articular abnormalities of the wrist under magnified and bright light conditions [19]. Whipple was one of the first surgeons to attempt arthroscopic management of scaphoid fractures [19]. His preliminary work set the stage for arthroscopic management of this common carpal fracture by many arthroscopic surgeons.

Arthroscopic stabilization provides direct visualization of the fracture reduction, particularly rotation, and the precise site for screw insertion with limited surgical dissection. This may allow for greater range of motion and early return to competition or employment. Fractures of the scaphoid are best visualized with the arthroscope in the midcarpal space. Fractures of the proximal pole are best seen with the arthroscope in the ulnar midcarpal portal, while fractures of the waist are best visualized with the arthroscope in the radial midcarpal portal. Associated soft tissue injuries may occur with a fracture of the scaphoid can be arthroscopically detected and managed at the same sitting.

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W.B. Geissler, M.D. (✉)
Department of Orthopaedic Surgery and Rehabilitation,
University of Mississippi Medical Center,
2500 North State Street, Jackson, MS 39216, USA
e-mail: 3doghill@msn.com

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The indications and techniques of arthroscopic management of acute scaphoid fractures and selected nonunions are described in this chapter.

Diagnostic Imaging

Posterior/anterior and lateral radiographs are mandatory to assess the amount of displacement, angulation and alignment of a scaphoid fracture. Semisupinated and pronated views can provide additional information particularly in fractures of the proximal and distal poles of the scaphoid. It is helpful to place the wrist in ulnar deviation thereby extending the scaphoid in a posterior/anterior view for detection of fracture displacement. A nondisplaced fracture of the scaphoid may not become apparent on radiographs for several weeks post injury. It is important to immobilize the patient who presents with snuffbox tenderness to allow the pain to resolve or until a diagnosis has been confirmed radiographically.

Computer tomography (CT) parallel to the longitudinal axis of the scaphoid is useful to evaluate angulation, displacement, and healing. In this technique, the patient is placed prone with the arm extended overhead and the wrist radial deviated to obtain longitudinal access to the scaphoid. Coronal CT slices are obtained with supination of the forearm to a neutral position. CT evaluation is particularly helpful to determine scaphoid healing with nonoperative management of the scaphoid fracture is chosen. It is particularly important to return a contact athlete back to sports. One advantage of operative fixation is that the screw acts as an internal splint to stabilize the fracture and the exact time to return to competition is less critical compared with nonoperative management.

Treatment

Indications

Arthroscopic fixation may be performed for acute nondisplaced fracture of the scaphoid and for acute displaced fractures which are reducible. It is important in patients that have an acute nondisplaced fracture that the risks and benefits of arthroscopic stabilization compared with cast immobilization be discussed with the patient so that an informed decision can be made by the patient and associated family members. For acute scaphoid fractures that are reducible, the fracture may reduce by a number of techniques including manipulation of the wrist in a traction tower or joysticks inserted into the proximal and distal poles of the scaphoid. The reduction is best viewed with the arthroscope in the midcarpal space.

In addition, arthroscopic visualization of selected scaphoid nonunions may be performed. Slade and Geissler published their radiographic classifications for scaphoid nonunions (Table 19.1) [20]. Type I fractures are the result of a delayed presentation (4–12 weeks) after injury. Delayed presentation has been shown with a high incidence of nonunion. In Type II injuries, a fibrous union is present. A minimal fracture line may be seen on radiographs. It is important to note that the lunate is not rotated and there is no humpback deformity. In Type III injuries, minimal sclerosis is seen at the fracture site. The sclerosis is less than 1 mm in width, and again the lunate is note rotated and no humpback deformity is seen. In Type IV injuries, cystic formation is present at the nonunion site. The cystic formation may be between 1 and 5 mm in width. No humpback deformity or rotation of the lunate is seen on plain radiographs. In Type V injuries, the cystic changes are greater than 5 mm in width, and rotation of the lunate has occurred resulting in humpback deformity. The lunate has rotated to a position of dorsal intercalated segmental instability (DISI). In Type VI injuries, secondary degenerative changes have occurred with peaking of the radial styloid with spurring along the radial border of the scaphoid.

Table 19.1 Slade–Geissler classification of scaphoid nonunions

Type	Description
I	Delayed presentation at 4–12 weeks
II	Fibrous union, minimal fracture line
III	Minimal sclerosis <1 mm
IV	Cystic formation, 1–5 mm
V	Humpback deformity with >5 mm cystic change
VI	Wrist arthrosis

Arthroscopic stabilization of selected scaphoid nonunions is indicated in types I–IV. After a humpback deformity has occurred, arthroscopic stabilization is not recommended and open reduction and internal fixation is required to correct the humpback deformity and DISI rotation of the lunate.

Arthroscopic Techniques

Various arthroscopic assisted and percutaneous techniques for fractures of the scaphoid have been described in the literature [21–32]. Haddad and Goddard popularized the volar approach and the dorsal approach was popularized by Slade and colleagues [24, 26]. Geissler described his arthroscopic technique for viewing exact placement of the guide wire for eventual screw fixation [32].

Volar Percutaneous Approach

Haddad and Goddard popularized the volar percutaneous technique [24]. They recommended placing the patient supine with the thumb suspended in the Chinese finger trap. Placing the thumb under suspension allows ulnar deviation improving access to the distal pole of the scaphoid. A longitudinal 0.5 cm skin incision is made under fluoroscopic guidance over the most distal radial aspect of the scaphoid. Blunt dissection is carried down to expose the distal pole of the scaphoid. It is important to protect the cutaneous nerves as one dissects down to the distal pole of the scaphoid.

A percutaneous guide wire is then introduced into the scaphoid trapezial joint and advanced proximally and dorsally across the fracture site. The guide wire is inserted through a needle which is impaled onto the distal pole of the scaphoid. Using the needle helps to control the angulation of the guide wire. In addition, the bevel of the needle can help further direct the direction of the guide wire. The advantage of their technique by suspending the thumb in traction allows an almost 360° view of the position of the guide wire within the scaphoid. The length of the guide wire within the scaphoid is determined by placing a second guide wire next to the initial one and measuring the difference between the two. It is important when using a headless cannulated screw to use a screw 2–4 mm shorter than what is measured in the volar approach. A drill is inserted through a soft tissue protector and the scaphoid is reamed. A headless cannulated screw is placed over the guide wire. Occasionally, a second guide wire may be helpful to prevent rotation of the fracture fragments while the screw is being inserted.

Haddad and Goddard reported their initial results in a pilot study of 15 patients with acute scaphoid fractures [24]. Union was achieved in all patients in an average of 57 days (range 38–71 days). They found that the range of motion at the union was equal to that of the contralateral limb with their percutaneous technique and grip strength averaged 90 % at 3 months. The patients were able to return to sedentary work within 4 days and to manual work within 5 weeks.

The advantage of their technique is that it is fairly simple and straightforward and requires minimal specialized equipment. The disadvantage of the volar approach is that the screw may be placed slightly oblique to the mid waist fracture line in the scaphoid. The scaphoid is shaped like a cone with the widest part being distally and the smallest more proximally. It is harder to place the cannulated screw in the exact center of the scaphoid with starting at the wider distal pole of the scaphoid compared to the more narrow proximal pole.

Dorsal Percutaneous Approach

Joseph Slade was as pioneer in management of fractures of the scaphoid. He and his coworkers popularized the dorsal percutaneous approach [26, 27]. This technique became very popular because it involved limited surgical dissection and allowed arthroscopic evaluation and reduction of the scaphoid fracture. In his technique, the patient is placed in a supine position on the table with the arm extended. Several towels are placed under the elbow and support the forearm parallel to the floor. The wrist is then flexed and pronated under fluoroscopy until the proximal and distal poles of the scaphoid are aligned to perform a perfect cylinder. Continuous fluoroscopy is recommended as the wrist is flexed to obtain the true ring sign as the proximal and distal poles are aligned.

Under fluoroscopy, a 14-gauge needle is placed percutaneously in the center of the ring sign and parallel to the beam of the fluoroscopic unit. A guide wire is then inserted through the 14-gauge needle and driven across the central axis of the scaphoid from dorsal to volar until the guide wire comes into contact with the distal scaphoid cortex. Position of the guide wire is then evaluated under fluoroscopy in the lateral, posterior/anterior, and oblique planes while the wrist is maintaining flexion. It is important not to extend the wrist at this time as this may bend the guide wire. A second guide wire is then placed parallel to the first so that it touches the proximal pole of the scaphoid to determine the screw length. The difference in length between the two guide wires is measured. It is of vital importance that a screw at least 4 mm shorter is chosen when utilizing Slade's dorsal technique.

Once the screw length is determined, the primary guide wire is advanced volarly through a portion of the trapezium to exit the skin on the volar aspect of the hand. The wire is continued to be advanced volarly until it is flush with the proximal pole of the scaphoid dorsally so the wrist may now be extended.

The wrist is suspended in a traction tower and the radiocarpal and midcarpal spaces may be evaluated arthroscopically. The radiocarpal space is evaluated for any associated soft tissue injuries, and then the arthroscope is placed in the midcarpal space to evaluate the reduction of the scaphoid fracture. If the reduction of the scaphoid fracture is not determined to be satisfactory, the guide wire is continued to be advanced out volarly but yet it is still in the distal pole of the scaphoid. Joysticks may be placed at the proximal and distal poles of the scaphoid to facilitate reduction as viewed with the arthroscope in the midcarpal space. Once anatomic reduction has been obtained with the joysticks, the guide wire is then advanced proximally back into the proximal pole of the scaphoid.

The guide wire is then advanced back out dorsally with the wrist flexed once anatomic restoration of the scaphoid fracture has been obtained. It is important that blunt dissection continues around the guide wire dorsally to minimize risk of soft tissue impalement by the guide wire as it exits back out dorsally by the surrounding extensor tendons. A portion of the guide wire is still left out the volar aspect of the hand so if it breaks, easy access to the broken guide wire is possible. Through a soft tissue protector, the scaphoid is reamed over the guide wire and a headless cannulated screw is placed.

The dorsal approach has several advantages as the screw is inserted down the central axis of the scaphoid most perpendicular to the fracture site. This allows compression directly across the fracture site as compared to possibly more oblique orientation with the volar approach. The concern with the dorsal percutaneous approach is that as the wrist is hyperflexed to obtain the cylinder or ring sign, it may displace the scaphoid fracture creating a humpback deformity, which may be unstable. Reduction of the scaphoid should be evaluated with the arthroscope in the midcarpal space when utilizing this technique. Frequently, it takes a surgeon and a very capable assistant with the Slade technique.

Geissler Technique

The Geissler technique has the advantage of knowing the exact starting point for the guide wire as viewed directly with the arthroscope [33] (Video 19.1). There is no guesswork concerning the insertion point and location of the headless cannulated screw. It is the author's opinion that this technique is simpler than the dorsal percutaneous approach with the ring sign. The wrist is not hyperflexed, which could distract the scaphoid fracture and cause a possible humpback deformity.

The wrist is initially suspended in a wrist traction tower (Acumed, Hillsboro, OR) (Fig. 19.1). The wrist is flexed approximately 20–30° in the tower. The arthroscope is initially placed in the 3–4 portal to evaluate any associated soft tissue injuries and the 6-R portal is made. It is important when making the initial 3–4 portal that if one is to error, error slightly ulnar and proximal. If the 3–4 portal is made too radial or too distal, placement of the guide wire would be difficult. A 14-gauge needle is inserted through the 3–4 portal and the junction of the scapholunate interosseous ligament as it inserts onto the proximal pole of the scaphoid is palpated with the needle as viewed directly with the arthroscope in the 6-R portal (Fig. 19.2). Occasionally, some synovitis from the dorsal capsule may need to be debrided to facilitate visualization of the scapholunate interosseous ligament. It is important that as the needle is inserted through the 3–4 portal that it passes easily into the joint and does not impale through an extensor tendon. The proximal pole of the scaphoid is impaled once the needle is at the junction of the scapholunate interosseous ligament to the scaphoid (Fig. 19.3).

Fig. 19.1 The wrist is suspended in 10 lb of traction in the traction tower (Acumed, Hillsboro, OR). The suspension arm is out to the side, which facilitates arthroscopic and fluoroscopic reduction of fractures

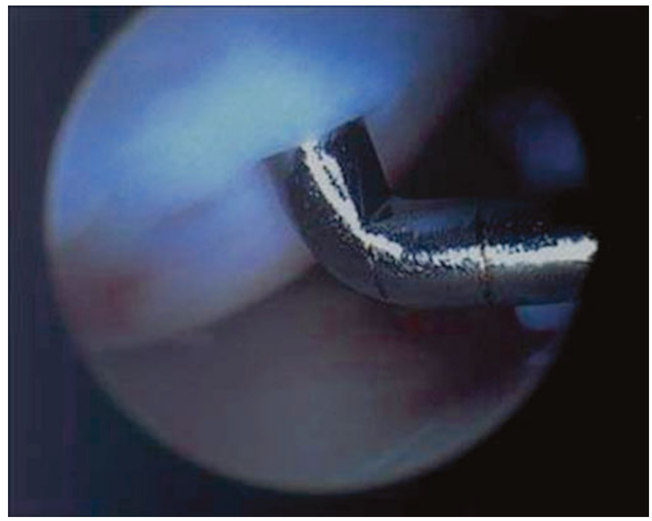

Fig. 19.2 Arthroscopic view with the arthroscope in the 6-R portal. The probe is placed in the 3–4 portal palpating the junction of the scapholunate interosseous ligament to the proximal pole of the scaphoid

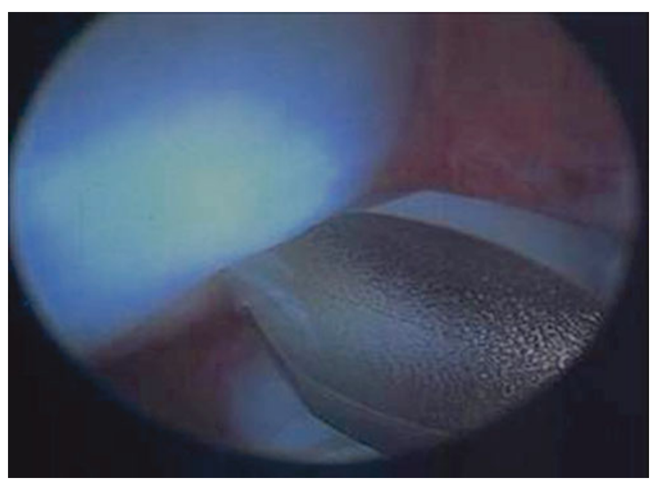

Fig. 19.3 Arthroscopic view with the arthroscope in the 6-R portal with a 14-gauge needle inserted through the 3–4 portal. The needle is palpating the junction of the scapholunate interosseous ligament to the proximal pole of the scaphoid and is impaled into the scaphoid

The wrist traction tower is then flexed and the starting point of the needle is confirmed under fluoroscopic visualization (Fig. 19.4). This technique allows for a consistent starting point of the very proximal pole of the scaphoid. The needle is then simply aimed toward the thumb under fluoroscopy, and a guide wire is placed through the needle down the central axis of the scaphoid to abut the distal pole (Fig. 19.5). The position of the guide wire is easily checked under fluoroscopy in the posterior/anterior, oblique, and lateral planes while rotating the forearm of the traction tower. The fluoroscopic image is not hindered by the support beam of the traction tower as it is off to the side. A second guide wire is then advanced against the proximal pole of the scaphoid and the length of the screw is determined by the difference of the two guide wires. Just as in the Slade technique, a screw at least 4 mm shorter than what is measured is recommended.

The reduction of the scaphoid may be evaluated with the arthroscope in the midcarpal portal. If anatomic reduction is confirmed arthroscopically, the guide wire is then advanced out the volar aspect of the hand. The scaphoid is then reamed with a cannulated reamer and a screw is placed (Figs. 19.6 and 19.7). The position of the screw is then checked in the posterior/anterior, oblique, and lateral planes under fluoroscopy with the wrist stabilized by the traction tower (Fig. 19.8).

It is important to evaluate the wrist both in the radiocarpal and midcarpal spaces after placement of the screw (Fig. 19.9).

Fig. 19.4 The traction tower (Acumed, Hillsboro, OR) is flexed down to verify the starting point of the proximal pole of the scaphoid

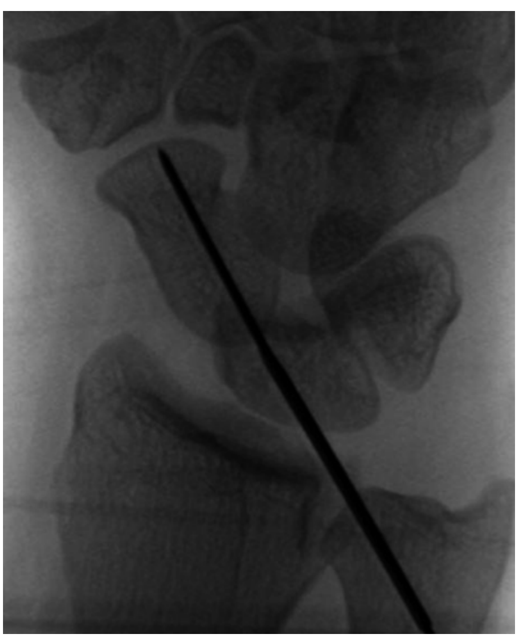

Fig. 19.5 Fluoroscopic view confirming ideal position of the starting point and guide wire through the central axis of the scaphoid fracture

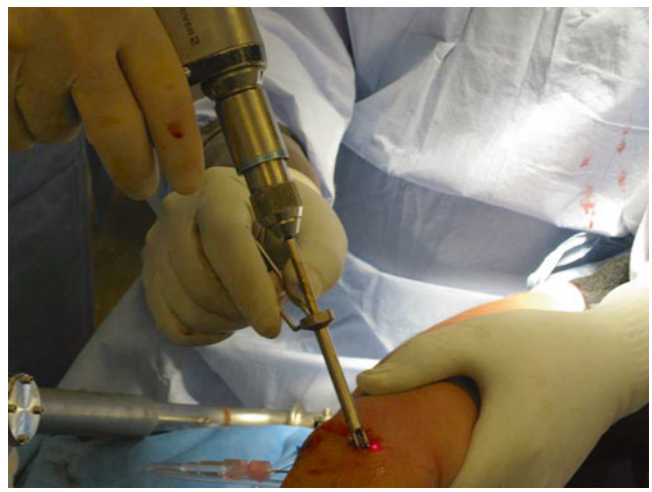

Fig. 19.6 Outside view showing reaming of the scaphoid through a soft tissue protector to protect the extensor tendons

Fig. 19.7 Outside view showing a headless cannulated screw being inserted over the cannulated guide wire stabilizing the fracture of the scaphoid

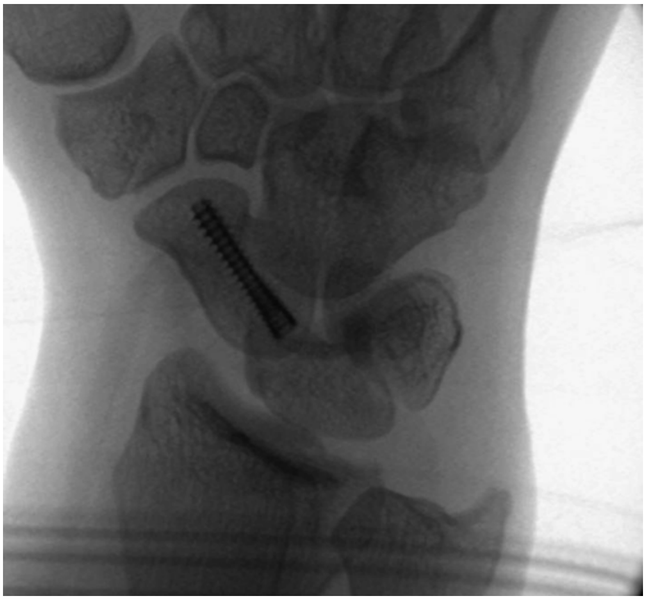

Fig. 19.8 Fluoroscopic oblique view showing ideal position of the headless cannulated screw inserted arthroscopically

Fig. 19.9 Arthroscopic view with the arthroscope in the radial midcarpal portal demonstrating anatomic reduction to the scaphoid fracture

It is particularly important to evaluate the radiocarpal space following screw placement because the screw may look well inserted in the scaphoid under fluoroscopy, but may still be slightly prominent proximally, which could potentially injure the articular cartilage of the scaphoid facet of the distal radius (Fig. 19.10)

Scaphoid Nonunions

Geissler and Slade described their use of Slade's dorsal percutaneous technique in 15 patients with a stable fibrous nonunion of the scaphoid [32]. There were 12 horizontal oblique fractures, two proximal pole fractures, and one transverse fracture in their series. The average time to presentation to surgery was 8 months. All patients underwent percutaneous dorsal fixation with a headless cannulated screw with no bone grafting. Eight of the 15 patients underwent CT evaluation postoperatively to evaluate healing. All patients healed their fractures in an average time of 3 months in their series without any bone grafting. The patients demonstrated excellent range of motion at their final follow-up because of minimal surgical dissection. Utilizing the Mayo modified score, there were 12 of 15 patients who had excellent results. Dorsal percutaneous fixation without bone grafting was recommended in most patients with a stable fibrous nonunion with no signs of humpback deformity of the scaphoid or rotation of the lunate into a DISI position. This study of evaluating patients with Type I through Type III scaphoid nonunions by Slade and Geissler's classification revealed a 100 % success rate of union.

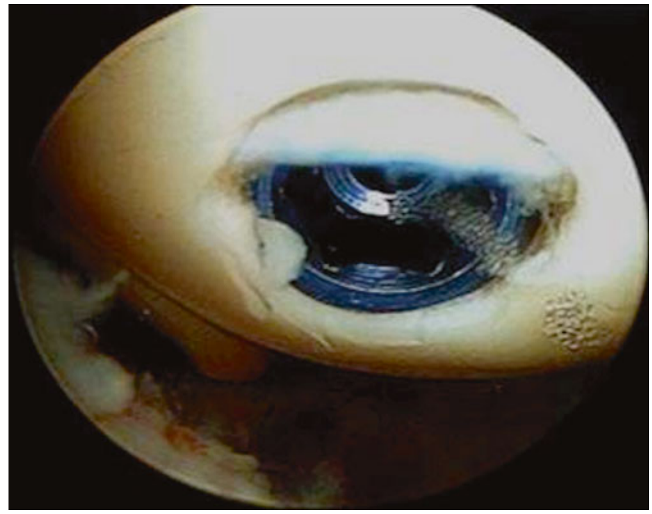

Fig. 19.10 Arthroscopic view with the arthroscope in the 3–4 portal confirming placement of the headless cannulated screw up into the scaphoid so as not to injure the articular cartilage of the distal radius

In patients who have a cystic scaphoid nonunion without a humpback deformity or rotation of the lunate, percutaneous cancellous bone grafting or injection of demineralized bone matrix (DBM) may be used. In Geissler's technique, the guide wire is placed as previously described [33]. The scaphoid is reamed through a soft tissue protector. A bone biopsy needle is filled with DBM putty. The needle is placed over the guide wire from dorsal to proximal and inserted into the drill hole directly into the nonunion site. The guide wire is then retracted distally out of the proximal pole of the scaphoid while still remaining into the distal pole of the scaphoid. The DBM is injected through the bone biopsy needle directly into the central hole of the scaphoid until resistance is felt (Fig. 19.11). Following injection of the DBM, the guide wire is advanced back dorsally through the bone

Fig. 19.11 Outside view showing insertion of DBM putty over the cannulated guide wire through a putty pusher into the scaphoid nonunion site

Fig. 19.12 Anterior/posterior radiograph demonstrating a transscaphoid perilunate dislocation

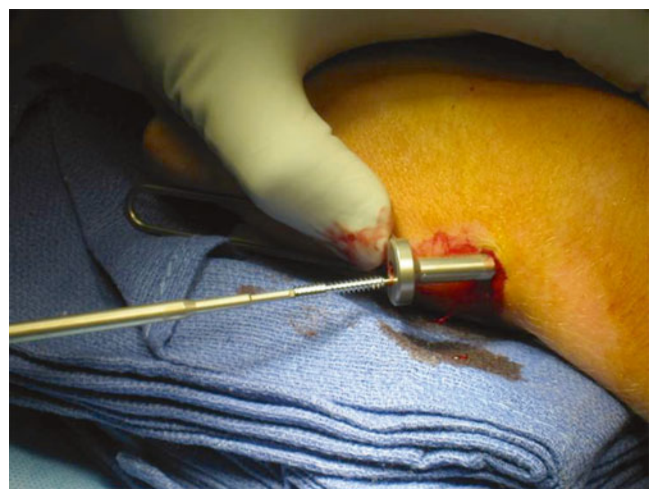

Fig. 19.13 Outside view showing placement of a SLIC screw (Acumed, Hillsboro, OR) placement across the lunotriquetral interval for a complete tear of the lunotriquetral osseous ligament

biopsy needle from volar to dorsal. In this manner, the guide wire passed back through the original reamed tract of the proximal pole of the scaphoid out dorsally. The bone biopsy needle is then removed, and the headless cannulated screw is placed over the guide wire.

Geissler reported his results of using 1 cc of DBM putty for cystic scaphoid nonunions of the scaphoid [33]. There were 15 patients in his series that were classified by the Slade and Geissler classification Type IV. Fourteen of 15 patients healed their cystic scaphoid nonunions utilizing this technique. Arthroscopic evaluation of the wrist from both the radiocarpal and midcarpal spaces showed no extravasation of the DBM into the joint.

Discussion

While cast immobilization of an acute nondisplaced fracture of the scaphoid is effective, there are certain disadvantages including muscle atrophy, joint contracture, and stiffness. Fractures or the scaphoid are common athletic injuries occurring especially in young men [34, 35]. Most nondisplaced acute fractures of the scaphoid have been reported to heal with nonunion rates of 10–15 %. However, union rates of 100 % for acute fractures of the scaphoid managed by percutaneous arthroscopic assisted fixation have been consistently reported in the literature [19–22].

Arthroscopic fixation of acute scaphoid fractures has several advantages. This can allow the patient to return quickly to the work force or to competition. Arthroscopic fixation allows for secure stabilization through limited surgical dissection, which may result in improved range of motion. Recently, the author has been working on stabilization of transscaphoid perilunar dislocations all arthroscopically without Kirschner wires and starting early range of motion (Figs. 19.12, 19.13, 19.14, 19.15, and 19.16). Early results have been very encouraging. In addition, arthroscopic fixation allows for the management of associated soft tissue injuries which may occur with a fracture of the scaphoid (Figs. 19.17, 19.18, and 19.19).

Arthroscopic fixation has also been shown to be beneficial in treating scaphoid nonunions Type I through Type IV with the classification scheme of Slade and Geissler [36]. In patients with a stable fibrous nonunion, stabilization with a

Fig. 19.14 Fluoroscopic view confirming ideal position of the SLIC screw across the injured lunotriquetral interval. Following this, the scaphoid fracture will be arthroscopically stabilized

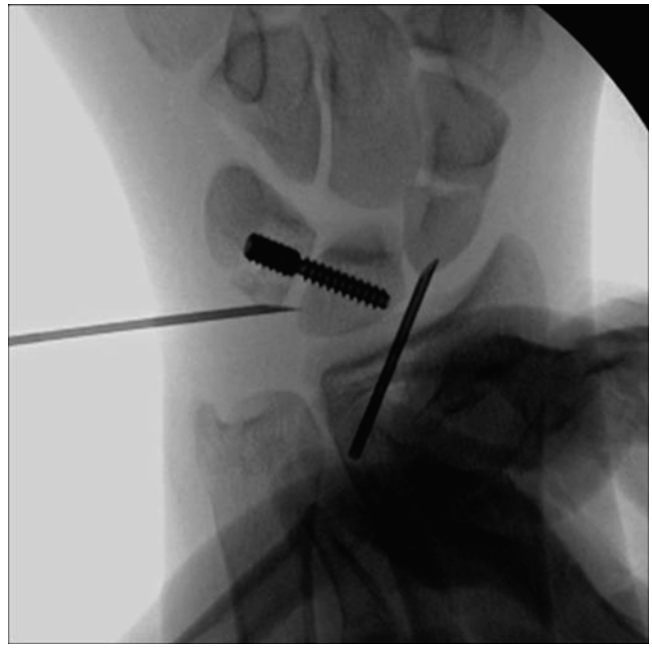

Fig. 19.16 Fluoroscopic view demonstrating the ideal starting point for the guide wire to stabilize the cannulated screw

Fig. 19.15 Following stabilization of the LT interval, the traction tower (Acumed, Hillsboro, OR) is being flexed to confirm the ideal starting point of the guide wire for the scaphoid fracture

Fig. 19.17 Fluoroscopic view showing stabilization both to the LT interval and scaphoid fracture and the perilunate dislocation. This patient will be started on immediate range of motion as no Kirschner wires were utilized, which can hamper rehabilitation

screw alone has been shown to be effective. In patients with cystic changes, arthroscopic stabilization and percutaneous injection of DBM or percutaneous cancellous bone grafting is an effective option [33].

Arthroscopic fixation limits the guess work concerning the exact location of the starting point of a guide wire and cannulated screw as compared to previously described percutaneous fluoroscopic techniques. The ideal starting point is at the most proximal pole of the scaphoid at the junction of the scapholunate interosseous ligament. It is very reproducible and easily confirmed under fluoroscopy without hyperflexion of the wrist causing a potential humpback

Fig. 19.18 Radiograph showing a great arc injury to the wrist involving the distal radius, scaphoid, capitate, and lunotriquetral interval

Fig. 19.19 Fluoroscopic view following arthroscopic reduction of the distal radius fracture, scaphoid fracture, and SLIC screw placement (Acumed, Hillsboro, OR) of the lunotriquetral interval. The capitate fracture was stabilized percutaneously

deformity of the scaphoid. Dorsal insertion of the screw enables central placement down the axis of the scaphoid as compared to oblique orientation through the volar approach.

It is important to remember that these two techniques are not indicated for those patients who have severe humpback deformity, which is not correctable, or for those patients who have advanced arthrosis of the radiocarpal joint (SNAC) [37].

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