

Clinical and Radiologic Outcomes After Scaphoid Fracture: Injury and Treatment Patterns in National Football League Combine Athletes Between 2009 and 2014



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Purpose: To report on the clinical and radiologic outcomes and complications after surgical treatment in National Football League (NFL) Combine athletes with a history of a scaphoid fracture. **Methods:** The medical records of 2,285 athletes participating in the NFL Combine from 2009 to 2015 were evaluated for a history of scaphoid, hand, or wrist injury. Clinical outcomes, including grip strength, pinch test, range of motion, and presence of pain and stiffness, were recorded. Imaging studies were evaluated for the percentage of healing, fixation treatment type, hardware complications, radiographic deformity, and presence of osteoarthritis. **Results:** Of the 2,285 athletes evaluated, 56 presented with a history of a scaphoid fracture. Most fractures were in the middle and proximal aspects of the scaphoid. Of the scaphoid fractures, 76% (43 players) were treated with screw fixation. Of the athletes, 36 (72%) had normal range of motion of the affected wrist, 52 (93%) reported no pain, and 44 (83%) reported no stiffness in the affected wrist. The grip strength and pinch strength were 91% and 96%, respectively, of the uninjured side. The fracture was healed in 75% of the cases; however, 34% had degenerative changes. Hardware complications were found in 15% of the athletes. **Conclusions:** Good clinical outcomes can be achieved after scaphoid fractures in prospective NFL athletes. However, the rates of nonunion (25%), degenerative changes (34%), and hardware complications (15%) in this study suggest the need for close postoperative radiographic follow-up in this population of patients because their athletic demands may lead to higher rates of the aforementioned complications. **Level of Evidence:** Level IV, retrospective study.

Scaphoid fractures account for up to 70% of all carpal fractures in athletes, usually affecting young male patients.¹ These injuries are usually associated with a traumatic event^{1,2}; however, stress fractures of the scaphoid have also been reported.³⁻⁶ Many scaphoid fractures presenting in the acute phase have “normal”

initial radiographs, which can sometimes lead to a missed or late diagnosis.² For this reason, one should have a high level of suspicion when assessing contact athletes with radial wrist pain, and computed tomography (CT) or magnetic resonance imaging (MRI) can be obtained to further assess for a nondisplaced fracture.²

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Although conservative treatment with immobilization provides good clinical outcomes in nondisplaced fractures,⁷ surgery is often recommended if there is displacement⁸ or a step-off greater than 1 mm.⁹ The risk of nonunion of displaced fractures can be as high as 17 times greater with immobilization treatment compared with surgical fixation.¹⁰ Complications after nonoperative treatment include symptomatic pseudarthrosis, malunion, and osteonecrosis,¹¹ whereas surgical complications also include symptomatic hardware, neurovascular injury, and persistent pain. Despite good functional outcomes and healing rates after nonoperative management, it often entails long-term immobilization that is not favorable for athletes and manual workers. Some authors have recommended surgical management of scaphoid fractures, regardless of the presence of diastasis in these patients, and reported good outcomes and a faster return to activity.¹²⁻¹⁴

The purpose of this study was to report on the clinical and radiologic outcomes and complications after surgical treatment in National Football League (NFL) Combine athletes with a history of a scaphoid fracture. We hypothesized that those with scaphoid fractures treated surgically would have good to excellent objective outcomes.

Methods

Study Design

The medical records of 2,285 players participating in the NFL Combine from 2009 to 2015 were evaluated for a history of scaphoid, hand, or wrist injury. Patients with a positive history and wrist and hand imaging examinations, including radiographs, CT scans, and/or MRI studies, were included in the study. All radiographs were obtained during the NFL Combine. All 56 players included in this study had plain radiographs of the wrist and carpal bones, 35 had both radiographs and CT scans, and 15 had MRI studies of the injured hand. All imaging studies were evaluated by 2 board-certified orthopaedic surgeons (G.M. and J.C.) for evidence of a scaphoid fracture or prior surgery for a scaphoid fracture, as well as for radiographic outcomes of interest. Inter-rater and intrarater agreement was assessed for scaphoid nonunion advanced collapse (SNAC) determination by use of a 2-way random-effects model to calculate the intraclass correlation coefficient (ICC). The ICC values were interpreted as follows: less than 0.40, poor agreement; 0.40 to 0.75, fair to good agreement; and greater than 0.75, excellent agreement.

Demographic Data and Clinical Outcomes

Demographic data, including age, injury date, side affected, and position, were recorded. In addition, grip strength, pinch strength, range of motion (ROM),

presence of pain, presence of stiffness, and associated carpal bone fractures were collected from the medical records.

Imaging Assessment

The imaging studies were evaluated, and the following data were recorded: Mayo classification for scaphoid fracture location (distal, middle, or proximal); percentage of healing on CT scans (<50% or >50%); fixation type (headless compression screws, Herbert screws, or pins and/or wires); hardware complications (including broken hardware or migration); and presence of other carpal fractures, deformity (flexion, ulnar deviation, radial deviation, or extension), or osteoarthritis on plain radiographs (classified by use of the 4 stages of the SNAC classification). In stage 1, arthrosis is localized to the radial side of the scaphoid and radial styloid; in stage 2, there is scaphocapitate arthrosis in addition to stage 1 findings; in stage 3, there is periscaphoid arthrosis (the proximal lunate and capitate may be maintained); and in stage 4, osteoarthritis is located throughout the entire radiocarpal joint and in the intercarpal joints. In addition, the scapholunate and scaphocapitate angles were measured from the lateral wrist radiographs. Only the plain radiographs with optimal projections for measuring the angles were included.

Results

Demographic Characteristics

After application of the exclusion criteria, a total of 56 athletes (2.5%) who participated in the NFL Combine from 2009 to 2015 had a history of a scaphoid fracture. All the athletes had a unilateral injury, and none had bilateral scaphoid fractures. All patients were men, and the mean age at follow-up was 22.1 years (range, 20-24 years). On the basis of the Mayo classification system, 4 players (9%) had distal fractures, 22 (50%) had fractures between the distal and proximal zones, and 18 (41%) had proximal fractures. The rates of middle and proximal scaphoid fractures were both significantly greater than the rate of distal fractures

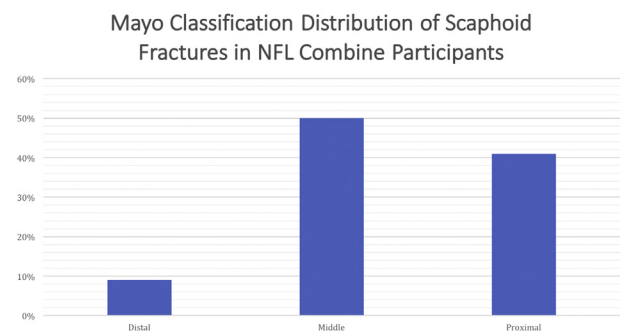


Fig 1. Distribution of fracture location based on Mayo classification system. (NFL, National Football League.)

Treatment of Scaphoid Fracture in NFL Combine Participants

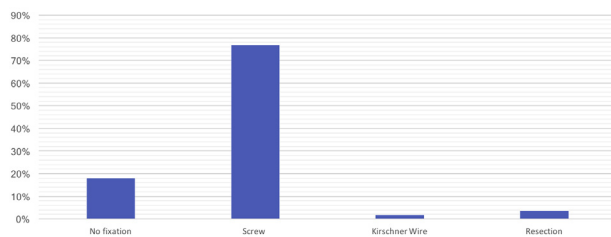


Fig 2. Distribution of scaphoid fracture treatment modalities in National Football League (NFL) Combine athletes. “No fixation” includes patients who underwent conservative management or casting.

($P < .001$). The difference in the rates of middle and proximal fractures was not statistically significant ($P = .521$). The distribution of fractures based on the Mayo classification system is presented graphically in [Figure 1](#).

Of the scaphoid fractures, 76% (43 players) were treated with screw fixation. The other treatment modalities included no fixation (10), Kirschner wire fixation (1), and resection (2). The treatment modalities and frequencies are reported in [Figure 2](#). Two patients underwent resection of the scaphoid and partial fusion of the carpal bones. In 1 patient there was fusion of the hamate and triquetrum, as well as fusion of the lunate and capitate, and the scaphoid was resected. In the other patient, there was a partial resection of the scaphoid and fusion of the remaining scaphoid to the capitate.

Clinical Findings

Of the athletes, 36 (72%) had normal ROM of the affected wrist whereas 14 (28%) had limited ROM. Moreover, 52 (93%) reported no pain and 44 (83%) reported no stiffness in the affected wrist. In 15 players (31%), the grip strength of the affected wrist was normal (100% of that on the uninjured side), and the mean grip strength on the injured side was 91% of that on the uninjured side. A normal pinch test score for the affected wrist (100% of the uninjured side) was reported in 11 players (52%), and the mean was 96% of that of the unaffected wrist ([Table 1](#)).

Radiographic Outcomes and Complications

All 56 players included in this study had plain radiographs of the wrist and carpal bones, 35 had both radiographs and CT scans, and 15 had MRI studies of the injured hand. Inter-rater reliability and intrarater reliability for the SNAC determination were 0.83 and 0.90, respectively. On plain radiographs, 36 of 44 players had a scapholunate angle in the normal range of 30° to 60° whereas 8 players had an abnormal scapholunate angle ($<30^\circ$ in 2 and $>60^\circ$ in 6). The

Table 1. Clinical Outcomes in Athletes With History of Scaphoid Fracture at National Football League Combine

Clinical Finding	Data
Range of motion (n = 50), n	
Normal	36 (72%)
Limited	14 (28%)
Pain (n = 56), n	
No pain	52 (93%)
Presence of pain	4 (7%)
Stiffness (n = 53), n	
No stiffness	44 (83%)
Presence of stiffness	9 (17%)
Arthritis (n = 56), n	
Absent	37 (66%)
Present	19 (34%)
Grip strength (n = 48)	
Normal, n	15 (31%)
Mean	91%
Pinch test (n = 21)	
Normal, n	11 (52%)
Mean	96%

NOTE. Arthritis was defined as stage 2, 3, or 4 according to the scaphoid nonunion advanced collapse classification system. Grip strength and pinch strength are given as a percentage of that on the uninjured side. The normal wrist range of motion is 75° of flexion and 70° of extension, with radial deviation of 20° and ulnar deviation of 35° .

mean scapholunate angle was $50.7^\circ \pm 11.5^\circ$, and the mean scaphocapitate angle was $60.3^\circ \pm 10.7^\circ$ ([Table 2](#)). In 75% of the athletes (n = 26), the scaphoid fracture was healed on CT evaluation, whereas 25% (n = 9) showed nonunion ([Fig 3](#)). Of the 13 patients with nonunion, 10 (77%) had Mayo type 1 (proximal) fractures, whereas the remaining 3 patients (23%) had Mayo type 2 (middle) fractures. Of the players with nonunion, 6 were treated with no fixation, 6 were treated with screw fixation, and 1 was treated with K-wire fixation before the NFL Combine. Among the 13 players with nonunion, 5 had a subjective feeling of wrist stiffness, 1 had pain, and 7 had decreased ROM.

Post-traumatic arthritis as defined by SNAC classification stage 2 or 3 was found in 19 athletes (34%) ([Table 1](#)). Among the 41 patients who had hardware implanted, complications were found in 22% (9 players) ([Fig 4](#)). Hardware complications included screw loosening, hardware breakage, and erosion on the neighboring carpal bones due to prominent hardware.

Table 2. Radiologic Measurements of Scapholunate and Scaphocapitate Angles in Athletes With History of Scaphoid Fracture at National Football League Combine

Radiographic Measure	Mean	Minimum	Maximum
Scapholunate angle (n = 44), $^\circ$	50.7	28.1	86.1
Scaphocapitate angle (n = 43), $^\circ$	60.3	36.2	80

NOTE. The normal scapholunate angle is 30° to 60° .

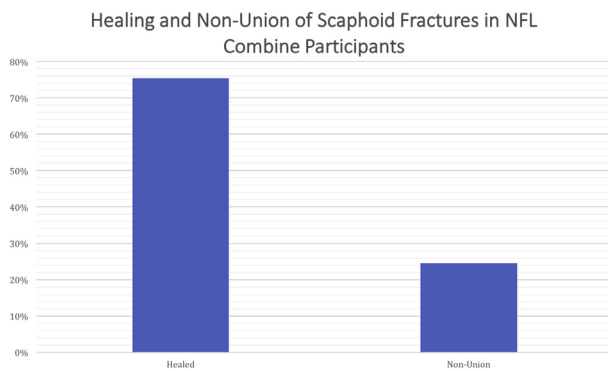


Fig 3. Healing rates of scaphoid fractures evaluated by computed tomography scans in National Football League (NFL) Combine athletes. Of the fractures, 75% ($n = 26$) were healed whereas 25% ($n = 9$) had nonunion. Hardware complications included screw loosening, hardware breakage, and erosion on the neighboring carpal bones.

Discussion

The most important finding of this study was that good clinical function with good grip strength, as well as normal ROM without pain or stiffness, was often achieved after treatment of scaphoid fractures. However, there were relatively high rates of hardware complications (15%), nonunion (25%), and degenerative changes (34%). This finding implies that these high-level athletes may often have sequelae that may limit their long-term function after a scaphoid fracture.

Dias et al.¹⁵ reported clinical and radiographic outcomes after nonoperative versus operative treatment of acute, nondisplaced scaphoid fractures at a mean of 8 years' follow-up. In their study with 71 patients with a mean age at injury of 30 years, they noted the mean grip strength to be 96% of that on the contralateral side in the operative group and 99% in the nonoperative group. The mean pinch strength was 96% and 100% in the operative and nonoperative groups, respectively, whereas mean ROM was 92% and 100%, respectively. In comparison, in our study the mean grip strength was 91% of that of the uninjured hand and the pinch strength was 96% of that on the injured side. There were no significant differences in these results. The 72% rate of full restoration of wrist ROM in this study, although not a true comparison with the results of this study, suggests inferior ROM results in prospective professional football players. The inferior ROM could be because of the injury itself, surgery, or rehabilitation. It was not possible to determine the cause of the inferior ROM results in this study. Furthermore, Dias et al. reported a 25.4% rate of joint space narrowing at the radioscapoid, scapholunate, or scaphotrapezium joint, which is similar to the 24% rate of arthritis in our study. Using a population more similar to that in our study, Rettig and Kollias¹⁶ documented the results of 12 athletes at a mean follow-up of 3 years treated with

internal fixation of acute, stable scaphoid fractures. They reported a very similar rate of return to full ROM (75%) to that in our study (72%). Rettig and Kollias reported that full grip strength returned in 83% of patients, as compared with 31% in our study; however, the mean grip strength in our study was 91%.

The radiographic union rate of 75% in this series is significantly lower than that in other series in which either nonoperative or operative treatment was used. Riestter et al.¹⁷ reported a greater than 90% radiographic union rate in midthird fractures in collegiate football players treated with casting, whereas Rettig et al.¹⁸ reported a 92% union rate in midthird fractures in athletes treated with cast immobilization. Bond et al.¹⁹ described a 100% union rate, Dias et al.¹⁵ reported a 98.4% union rate, Rettig and Kollias¹⁶ noted a 92.5% union rate, and Wozasek and Moser²⁰ found an 89% healing rate, all of which are significantly higher than the 75% rate identified in our study. In addition, Dias et al. described a 4.8% rate of hardware complications, significantly lower than the 15% rate in our study. By comparison, Bond et al. reported a 9% hardware complication rate in 11 active military personnel treated with percutaneous fixation. In our study the most common location of nonunion was in the proximal segment of the scaphoid. This finding agrees with previous studies^{11,21,22} and supports early diagnosis and treatment of proximal scaphoid fractures. However, given the limited number of patients with nonunion (13 players), a subanalysis by treatment modality was not feasible.

Limitations

We acknowledge some limitations in our study. The presence of scaphoid fractures was based on imaging records, and the number of asymptomatic players with scaphoid fractures would probably increase the prevalence of this injury. The Mayo classification used in this study was performed after the initial treatment; therefore, fractures that were healed at the time of the study could not be classified. All patients underwent the injury and treatment before the NFL Combine, and unfortunately, it was not always easy to obtain the data

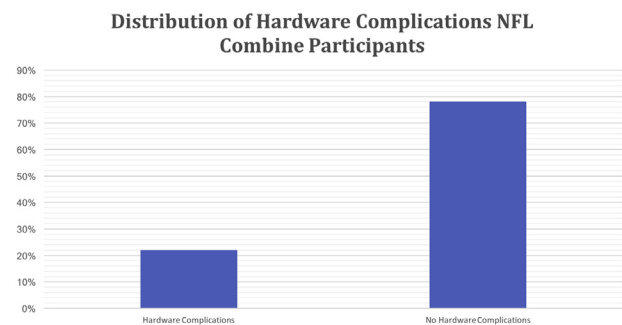


Fig 4. Hardware complications after scaphoid fracture surgery in National Football League (NFL) Combine athletes.

on the time between the injury and the treatment, as well as between the injury and the NFL Combine. This information was not always accurate and we opted not to include it, given that even with National Collegiate Athletic Association injury database data, the dates were not always complete; however, it was well documented that the patient had a true scaphoid fracture. As with other retrospective studies, as well as studies depending on reports from athletes, there was a recall bias associated with the study.

Conclusions

Good clinical outcomes can be achieved after scaphoid fractures in prospective NFL athletes. However, the rates of nonunion (25%), degenerative changes (34%), and hardware complications (15%) seen on imaging studies suggest the need for close postoperative radiographic follow-up in this population of patients because their athletic demands may lead to higher rates of the aforementioned complications.

References

1. Rettig AC, Patel DV. Epidemiology of elbow, forearm, and wrist injuries in the athlete. *Clin Sports Med* 1995;14:289-297.
2. Rettig AC. Athletic injuries of the wrist and hand. Part I: Traumatic injuries of the wrist. *Am J Sports Med* 2003;31:1038-1048.
3. Manzione M, Pizzutillo PD. Stress fracture of the scaphoid waist. A case report. *Am J Sports Med* 1981;9:268-269.
4. Matzkin E, Singer DI. Scaphoid stress fracture in a 13-year-old gymnast: A case report. *J Hand Surg Am* 2000;25:710-713.
5. Yamagiwa T, Fujioka H, Okuno H, Tomatsuri M, Tanaka J, Yoshiya S. Surgical treatment of stress fracture of the scaphoid of an adolescent gymnast. *J Sports Sci Med* 2009;8:702-704.
6. Nakamoto JC, Saito M, Medina G, Schor B. Scaphoid stress fracture in high-level gymnast: A case report. *Case Rep Orthop* 2011;2011:492407.
7. Ibrahim T, Qureshi A, Sutton AJ, Dias JJ. Surgical versus nonsurgical treatment of acute minimally displaced and undisplaced scaphoid waist fractures: Pairwise and network meta-analyses of randomized controlled trials. *J Hand Surg Am* 2011;36:1759-1768.e1.
8. Reigstad O, Thorkildsen R, Grimsgaard C, Melhuus K, Rokkum M. Examination and treatment of scaphoid fractures and pseudarthrosis. *Tidsskr Nor Laegeforen* 2015;135:1138-1142.
9. Singh HP, Taub N, Dias JJ. Management of displaced fractures of the waist of the scaphoid: Meta-analyses of comparative studies. *Injury* 2012;43:933-939.
10. Holzhaider JC, Sibley MD, Taylor AH, Singh PJ, Gray RD, Hunt GR. The social structure of New Caledonian crows. *Anim Behav* 2011;81:83-92.
11. Rhemrev SJ, Ootes D, Beeres FJ, Meylaerts SA, Schipper IB. Current methods of diagnosis and treatment of scaphoid fractures. *Int J Emerg Med* 2011;4:4.
12. Buijze GA, Doornberg JN, Ham JS, Ring D, Bhandari M, Poolman RW. Surgical compared with conservative treatment for acute nondisplaced or minimally displaced scaphoid fractures: A systematic review and meta-analysis of randomized controlled trials. *J Bone Joint Surg Am* 2010;92:1534-1544.
13. Majeed H. Non-operative treatment versus percutaneous fixation for minimally displaced scaphoid waist fractures in high demand young manual workers. *J Orthop Traumatol* 2014;15:239-244.
14. Modi CS, Nancoo T, Powers D, Ho K, Boer R, Turner SM. Operative versus nonoperative treatment of acute undisplaced and minimally displaced scaphoid waist fractures—A systematic review. *Injury* 2009;40:268-273.
15. Dias JJ, Dhukaram V, Abhinav A, Bhowal B, Wildin CJ. Clinical and radiological outcome of cast immobilisation versus surgical treatment of acute scaphoid fractures at a mean follow-up of 93 months. *J Bone Joint Surg Br* 2008;90:899-905.
16. Rettig AC, Kollias SC. Internal fixation of acute stable scaphoid fractures in the athlete. *Am J Sports Med* 1996;24:182-186.
17. Riester JN, Baker BE, Mosher JF, Lowe D. A review of scaphoid fracture healing in competitive athletes. *Am J Sports Med* 1985;13:159-161.
18. Rettig AC, Weidenbener EJ, Gloyeske R. Alternative management of midthird scaphoid fractures in the athlete. *Am J Sports Med* 1994;22:711-714.
19. Bond CD, Shin AY, McBride MT, Dao KD. Percutaneous screw fixation or cast immobilization for nondisplaced scaphoid fractures. *J Bone Joint Surg Am* 2001;83:483-488.
20. Wozasek GE, Moser KD. Percutaneous screw fixation for fractures of the scaphoid. *J Bone Joint Surg Br* 1991;73:138-142.
21. Winston MJ, Weiland AJ. Scaphoid fractures in the athlete. *Curr Rev Musculoskelet Med* 2017;10:38-44.
22. Ferguson DO, Shanbhag V, Hedley H, Reichert I, Lipscombe S, Davis TRC. Scaphoid fracture non-union: A systematic review of surgical treatment using bone graft. *J Hand Surg Eur Vol* 2016;41:492-500.