Distal Radius Fractures in Athletes: Approaches and Treatment Considerations

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Abstract: Fractures of the distal radius are common injuries in both athletes and nonathletes. Management is dictated by the nature of the fracture and the patient's level of competition, age, and sport-specific demands. Treatment strategies range from nonoperative treatment for stable injuries to primarily operative treatment for unstable fractures, particularly in active athletes. Once the decision has been made to treat a distal radius fracture operatively, a wide variety of fixation options are available. However, no technique has proven superior to all others, and no single method of fixation will lead to acceptable results in all types of distal radius fractures. This study will highlight important considerations when treating distal radius fractures in athletes, describe the various fixation options available, and discuss our method for determining the fixation needs of each fracture.

Key Words: distal radius fracture, athlete, open reduction internal fixation, fragment-specific fixation, columnar fixation, volar locked plating

(*Sports Med Arthrosc Rev* 2014;22:29–38)

Distal radius fractures are the most common fractures encountered in the emergency department and account for 3% of all upper extremity injuries.[1] They occur in patients of all ages, from preadolescents to the elderly, and in athletes from all competition levels, from recreational to professional. Over one third of all fractures in preadolescents are sports-related, and the most common fracture in this age group is the distal radius fracture.[2] Distal radius fractures account for 23% of sport-related fractures in adolescents[3] and 17% in adults.[4] Wrist fractures are the seventh most commonly reported injury in the National Football League and account for approximately 5% of all injuries in professional football players.[5]

Although distal radius fractures are among the most common sports-related fractures, only 12% of distal radius fractures in adults are sports-related.[4] The vast majority of evidence that guides management and postoperative rehabilitation in distal radius fractures is limited to low-velocity fragility fractures. Despite the lack of literature focusing on sports-related distal radius fractures, the treatment principles remain the same in athletes and nonathletes. Treatment decisions are influenced by the age of the patient, the general health and activity level of the patient, and the characteristics of the fracture itself. Although closed reduction and casting or splinting remains the mainstay of treatment for stable or nondisplaced fractures, surgical stabilization is generally necessary for treatment of unstable fractures, particularly in active athletes.

We begin with a discussion of important characteristics specific to athletes with distal radius fractures to be considered when treating this patient population. This is followed by an overview of our approach to distal radius fractures in athletes, including nonoperative treatment, available options for fixation, and how we determine the particular needs of each fracture for stabilization. We feel that the decision to proceed with a specific form of fixation, rather than the incision and fixation itself, is the primary determinant of outcome.

DISTAL RADIUS FRACTURES IN ATHLETES

With few exceptions, evaluation and treatment of distal radius fractures in athletes follows the treatment principles of all distal radius fractures. Stable fractures may be casted or splinted until union, followed by a rehabilitation protocol designed to maximize range of motion and strength. Unstable fractures are best treated with surgical stabilization. However, the athlete presents several differences from the general population that potentially affect treatment decisions and outcomes. Differences include patient age, sex, bone quality, fracture pattern, and goals of treatment.

Sports-related distal radius fractures tend to occur in a younger population than the routine fragility fracture typically seen in the elderly. In a prospective study of distal radius fractures that presented to one institution, the average age of sports-related distal radius fractures was 31 years, whereas the average age of the general population of distal radius fractures was older than 50 years.[6] Sports-related fractures were significantly more common in male individuals, and male individuals with sports-related distal radius fractures were on average 19 years younger compared with female individuals with sports-related distal radius fractures.

The implications of a younger patient population affect both operative and nonoperative treatment. Many distal radius fractures seen in adolescents and preadolescents may be successfully treated nonoperatively because of the impressive ability of children to remodel.[3] Advanced age, as defined by 60 years of age or older, is the most predictive factor of instability and malalignment after closed treatment.[7,8] Taken together, the treating surgeon may be more likely to consider surgical management in older patients than in younger patients. However, goals of anatomic restoration of the distal radius and return of full function are more stringent in younger patients, and younger patients tolerate surgical procedures better than elderly patients. Although elderly patients may have multiple medical comorbidities to consider when deciding between surgical and nonsurgical management, young

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Disclosure: One or more authors receive royalties, speaking honorarium, and research support from Trimed Inc.
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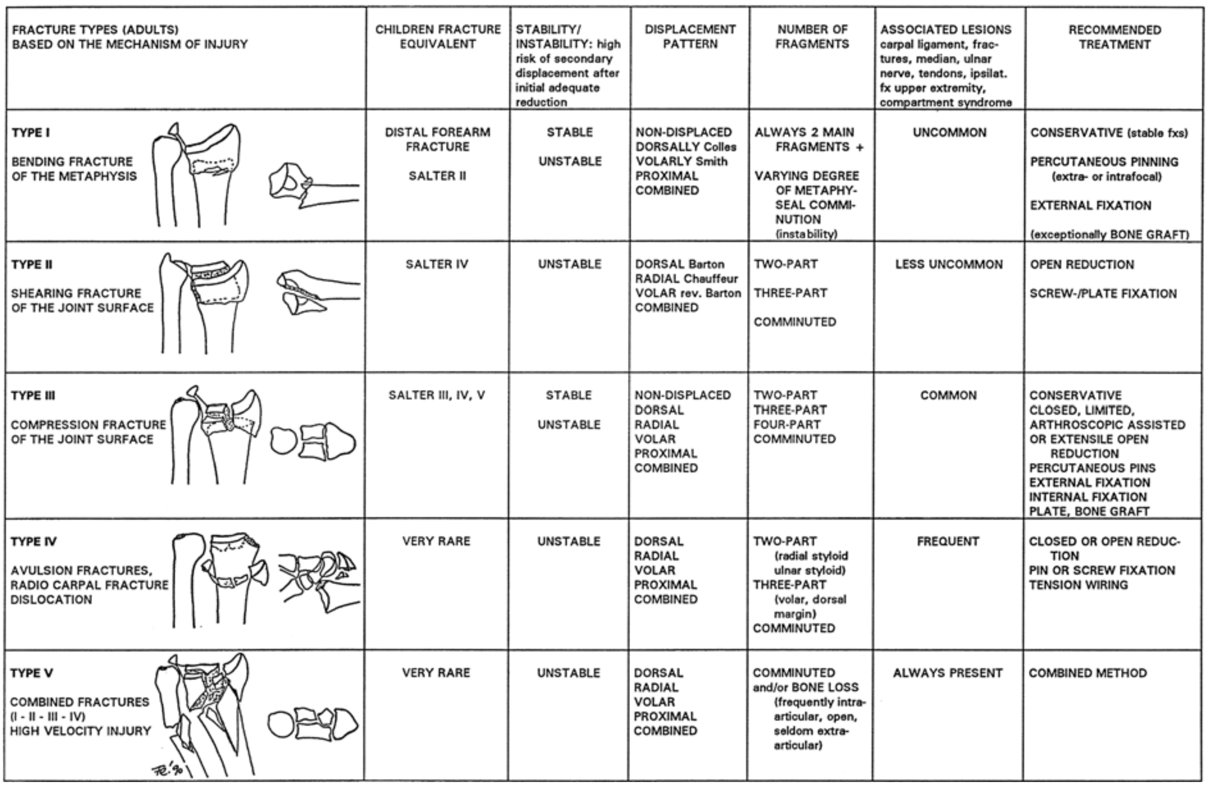
athletes often are healthy. As the population ages, more elderly patients are participating in recreational sports and sustaining distal radius fractures that necessitate careful consideration of the risks and benefits of surgical management.

Young age also has beneficial effects on bone quality. Younger men have increased volumetric bone mineral density compared with older men.[9] Athletes have also been shown to have better bone quality than nonathletes in both the upper and lower extremity, independent of age.[10–13] This improved bone quality improves the surgeon's ability to successfully reconstruct comminuted fractures, decreases the need for bone grafting, and affects the fracture pattern seen in athletes.

Fracture patterns depend primarily on injury mechanism and patient characteristics. Not surprisingly, distal radius fracture patterns in athletes tend to differ from patterns seen in nonathletes. In a retrospective review of 740 snowboarders who sustained distal radius fractures, 38% of fractures were simple nonarticular bending fractures (type A2), 27% were simple articular fractures (type C1), 17.3% were comminuted nonarticular fractures (type A3), and 11.8% were articular fractures with metaphyseal comminution (type C2). Only 4.3% of fractures were partial articular (type B1 and B3) and 2.8% were comminuted articular fractures (type C3). Snowboarders who were more experienced were more likely to sustain more complex fractures, whereas beginners were more likely to sustain simple fractures.[14] In contrast, in the general population of distal radius fractures, 56% to 79% of fractures are nonarticular bending fractures and 15% to 30% are articular.[15,16] The incidence of articular fractures, however, increases with increasing age.[15]

Distal radius fractures are often accompanied by soft tissue injuries about the wrist, and this may be particularly true in athletes.[17,18] If not addressed appropriately, these associated injuries negatively affect rehabilitation and return to sport. Hanker recommends performing an arthroscopic-assisted reduction in distal radius fractures in athletes. In 173 athletes with distal radius fractures treated in this manner, he found triangular fibrocartilage complex tears in 61% of patients, carpal instability in 20%, including complete scapholunate ligament tears in 8% and full-substance lunotriquetral ligament tears in 12%, evidence of perilunate injury in 8%, and distal radioulnar joint (DRUJ) instability in 9% of patients. Osteochondral fractures were found in 22% of cases, often on the inferior surface of the lunate, and 18% of the cases had articular loose bodies. Although widespread availability of magnetic resonance imaging may preclude the routine use of arthroscopic evaluation, one must clearly have a high index of suspicion of associated injuries in distal radius fractures in athletes.

Perhaps, the greatest difference in managing athletes with distal radius fractures is the real or perceived pressure on the physician to minimize the patient's time away from the sport.[19] The decision on when to allow an athlete to return to sport can be difficult, and available evidence specific to distal radius fractures is limited to expert



FRACTURE TYPES (ADULTS) BASED ON THE MECHANISM OF INJURY	CHILDREN FRACTURE EQUIVALENT	STABILITY/ INSTABILITY: high risk of secondary displacement after initial adequate reduction	DISPLACEMENT PATTERN	NUMBER OF FRAGMENTS	ASSOCIATED LESIONS carpal ligament, fractures, median, ulnar nerve, tendons, ipsilat. fx upper extremity, compartment syndrome	RECOMMENDED TREATMENT
TYPE I BENDING FRACTURE OF THE METAPHYSIS	DISTAL FOREARM FRACTURE SALTER II	STABLE UNSTABLE	NON-DISPLACED DORSALLY Colles VOLARLY Smith PROXIMAL COMBINED	ALWAYS 2 MAIN FRAGMENTS + VARYING DEGREE OF METAPHYSEAL COMMINUTION (instability)	UNCOMMON	CONSERVATIVE (stable fxs) PERCUTANEOUS PINNING (extra- or intrafocal) EXTERNAL FIXATION (exceptionally BONE GRAFT)
TYPE II SHEARING FRACTURE OF THE JOINT SURFACE	SALTER IV	UNSTABLE	DORSAL Barton RADIAL Chauffeur VOLAR rev. Barton COMBINED	TWO-PART THREE-PART COMMINUTED	LESS UNCOMMON	OPEN REDUCTION SCREW-/PLATE FIXATION
TYPE III COMPRESSION FRACTURE OF THE JOINT SURFACE	SALTER III, IV, V	STABLE UNSTABLE	NON-DISPLACED DORSAL RADIAL VOLAR PROXIMAL COMBINED	TWO-PART THREE-PART FOUR-PART COMMINUTED	COMMON	CONSERVATIVE CLOSED, LIMITED, ARTHROSCOPIC ASSISTED OR EXTENSILE OPEN REDUCTION PERCUTANEOUS PINS EXTERNAL FIXATION INTERNAL FIXATION PLATE, BONE GRAFT
TYPE IV AVULSION FRACTURES, RADIO CARPAL FRACTURE DISLOCATION	VERY RARE	UNSTABLE	DORSAL RADIAL VOLAR PROXIMAL COMBINED	TWO-PART (radial styloid ulnar styloid) THREE-PART (volar, dorsal margin) COMMINUTED	FREQUENT	CLOSED OR OPEN REDUCTION PIN OR SCREW FIXATION TENSION WIRING
TYPE V COMBINED FRACTURES (I - II - III - IV) HIGH VELOCITY INJURY	VERY RARE	UNSTABLE	DORSAL RADIAL VOLAR PROXIMAL COMBINED	COMMINUTED and/or BONE LOSS (frequently intra-articular, open, seldom extra-articular)	ALWAYS PRESENT	COMBINED METHOD

FIGURE 1. The Fernandez classification of distal radius fractures.[22] The image is courtesy of Elizabeth Martin, MS, FAMI, and she is the copyright holder. Adaptations are themselves works protected by copyright. So in order to publish this adaptation,authorization must be obtained both from the owner of the copyright in the original work and from the owner of copyright in the translation or adaptation.

opinion[17,20] and case series.[6,21] Neither of the case series describes guidelines or a protocol for return to sport.

Lawson et al[21] retrospectively reviewed 225 sports-related distal radius fractures. In their study, 126 (56%) of the fractures were either nondisplaced or minimally displaced and "required protection for a few weeks in a forearm cast." Ninety-five (42%) fractures required manipulation before cast application, and only 4 fractures underwent primary open reduction and internal fixation. Twenty-seven (12%) of these fractures were subsequently deemed unstable at 1 week: 16 of these were placed in an external fixator; 7 underwent open reduction, bone grafting, and percutaneous fixation; 2 underwent open reduction and internal fixation; and 2 underwent remanipulation. Only 131 patients responded to the return to sport questionnaire at an average of 27 months after injury, and only 72.5% of patients returned to their original sport.

Robertson and colleagues reviewed 367 soccer-related fractures in athletes of all levels. Seventy-three of these fractures were distal radius fractures. Only 7 (9.6%) distal radius fractures were managed surgically. Follow-up data were available for 62 (85%) patients; 79% of these patients returned to full soccer at an average of 8.9 weeks after injury. However, 21% of these patients reported persistent symptoms, and only 1 patient reported persistent symptoms that affect soccer playing.

In the absence of supporting evidence or defined protocols, a surgeon must decide when to allow return to sport on an individual basis. Different sports have different demands on the wrist, but many sports present the risk of falling on the wrist. In general, return to sport should only occur after stable union and completion of a specific, structured rehabilitation protocol designed to regain maximal strength and normal kinematics. Sound clinical judgment and orthopedic principles should never be compromised to allow an athlete to return to competition sooner.[17,19] Although there is no scientific data to support specific guidelines, we generally use a lower limit of 80% of

FIGURE 2. Posteroanterior (A) and facet lateral (B) radiographs of a dorsal bending, nonarticular distal radius fracture treated with a volar locked plate. Copyright 2013 by Scott W. Wolfe, MD. For permission to reuse contact wolfes@hss.edu. Adaptations are themselves works protected by copyright. So in order to publish this adaptation, authorization must be obtained both from the owner of the copyright in the original work and from the owner of copyright in the translation or adaptation.

uninjured wrist range of motion and 80% of uninjured grip strength as criteria for return to play after solid fracture healing.

APPROACH

After a focused physical examination, evaluating for concomitant injury, open fracture, acute carpal tunnel syndrome, or tendon rupture, we rely mainly on plain radiography to evaluate the fracture pattern. The first and most challenging determination to be made is whether a fracture is stable or unstable. Failing to identify fractures that will collapse with conservative treatment leads to prolonged overall treatment, increased cost, potential for subacute surgical intervention, and digital stiffness.[22] We rely on the factors described by Lafontaine et al[8] and MacKenney et al[7] to attempt to predict the stability of acute distal radius fractures. The 4 factors associated with instability presented by Lafontaine and colleagues were older than 60 years of age, dorsal comminution, dorsal angulation > 20 degrees, articular radiocarpal fracture, and ulnar fracture. The number of these factors present was linearly correlated with loss of reduction after closed treatment, and the authors concluded that fractures presenting with ≥3 of these instability factors should be considered for surgery or at least close radiographic follow-up. MacKenney and colleagues confirmed that advanced age, dorsal comminution, and loss of radial length were most predictive of malalignment at healing. It should be emphasized that both of these studies used injury films, rather than postreduction films, to predict fracture stability.

Nonoperative Treatment

We reserve nonoperative treatment for stable, nonarticular or stable, nondisplaced articular fractures without the above instability factors. In particular, in competitive athletes, we avoid trials of nonoperative treatment when it is likely that reduction will be lost. However, we are more likely to attempt a trial of nonoperative treatment in young patients or in older patients who only participate in recreational athletics. For truly nondisplaced fractures, we place the patient in a short-arm cast for 4 weeks, followed by a removable splint until the patient is comfortable. For displaced fractures with a stable pattern, we first perform a closed reduction; thereafter, patients are immobilized for 2 weeks in a sugar tong splint. Patients are reexamined weekly using serial radiographs to identify signs of early loss of reduction. If the fracture alignment remains satisfactory, the sugar tong is converted to a well-molded short-arm cast at 2 or 3 weeks and kept for a total of 6 weeks.

Finger range-of-motion exercises are initiated immediately for patients in splints and passive and active shoulder, elbow, and forearm motion are encouraged as soon as pain has subsided. The cast is typically removed at 5 or 6 weeks, and a removable thermoplastic splint is applied for an additional 2 to 4 weeks, during which wrist range-of-motion exercises are initiated. Strengthening begins after fracture union, typically 6 to 8 weeks, and athletes typically are allowed to return to light activity at 2 months. Full activity is restricted until at least 80% strength has been regained. Return to competitive sport is determined by the patient's rehabilitation and the amount of possible contact in the patient's sport. A playing cast may be an option for a highly competitive athlete who needs to return to sport before full rehabilitation.

FIGURE 3. Facet lateral radiograph illustrating late postoperative volar subluxation of the carpus after a locked volar plate was unable to capture the volar ulnar fragment. Copyright 2013 by Scott W. Wolfe, MD. For permission to reuse contact wolfes@hss.edu. Adaptations are themselves works protected by copyright. So in order to publish this adaptation, authorization must be obtained both from the owner of the copyright in the original work and from the owner of copyright in the translation or adaptation.

Fixation Options

Once a fracture has been determined to be unstable, and thus a candidate for internal fixation, many different options exist for fixation. Although it is widely accepted that restoration and maintenance of the anatomy of the distal radius is closely associated with optimal functional outcome,[23–27] available evidence does not support a single method of fixation over all others.

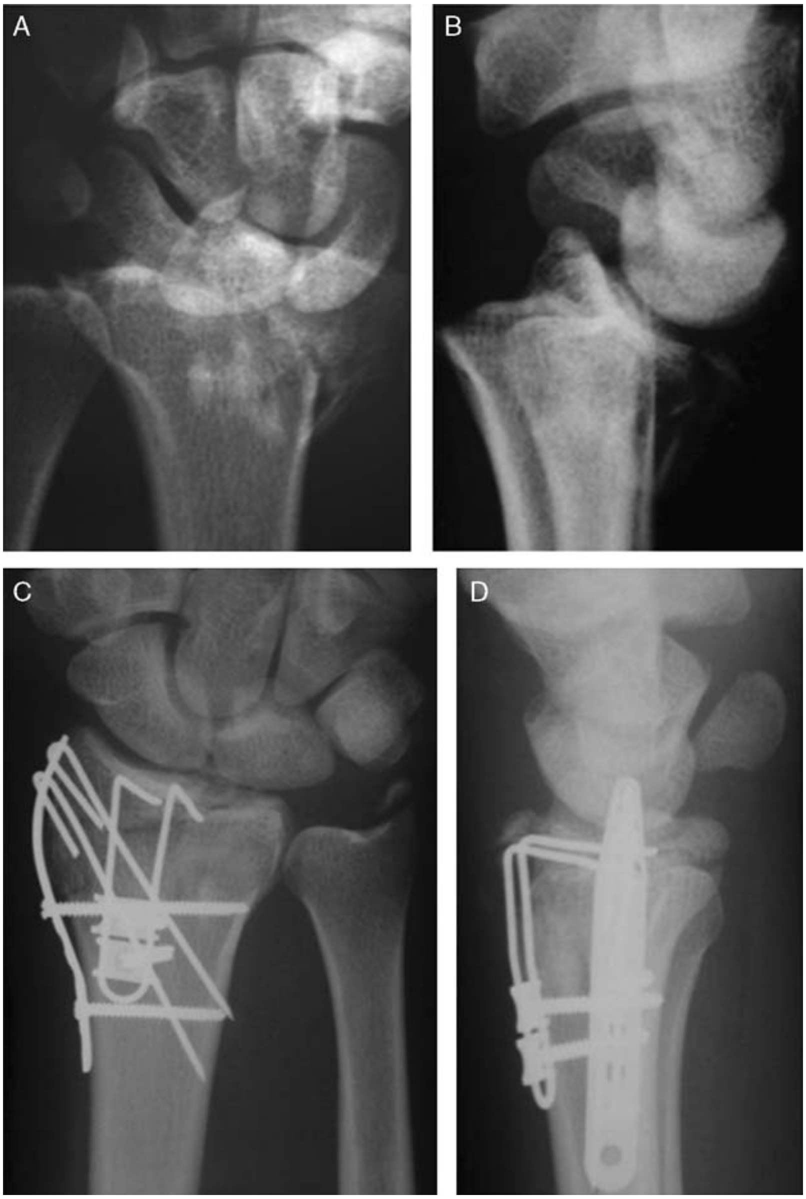


FIGURE 4. Posteroanterior (A) and facet lateral (B) radiographs of a dorsal articular shear fracture in a 20-year-old hang glider. This fracture was treated with fragment-specific fixation of the dorsal fragment and radial styloid. Two-week postoperative posteroanterior (C) and facet lateral (D) radiographs, showing restoration of carpal alignment, radial length, articular reduction, radial inclination, and volar tilt. Copyright 2013 by Scott W. Wolfe, MD. For permission to reuse contact wolfes@hss.edu. Adaptations are themselves works protected by copyright. So in order to publish this adaptation, authorization must be obtained both from the owner of the copyright in the original work and from the owner of copyright in the translation or adaptation.

Fixation choices include locked volar plating, locked dorsal plating, fragment-specific (or multi-columnar) fixation, external fixation with or without additional percutaneous Kirschner wires, and distraction plate fixation. Many biomechanical[28–31] and clinical studies[32–37] have compared volar and dorsal plating. Volar plating is biomechanically equivalent to dorsal plating and appears to result in slightly improved clinical outcomes.[32–35] Although volar plating results in increased rates of carpal tunnel syndrome and neuropathy, dorsal plating results in increased rates of tendonopathy or rupture.[36,37]

Fragment-specific (or multi-column) fixation refers to using a combination of ≥ 2 small plates to address individual fracture fragments. These ultrathin constructs have been shown to have equivalent or superior biomechanical stiffness to augmented external fixation,[38] dorsal internal fixation,[39] and volar fixed angle internal fixation.[40,41] Many groups have reported their clinical experience with fragment-specific fixation.[42–48] These case series all reported good to excellent radiographic and functional outcomes in most patients, with 5% to 10% rates of painful hardware and hardware removal.

FIGURE 5. Facet lateral (A) and posteroanterior (B) radiographs showing an articular compression fracture. Posteroanterior (C) and facet lateral (D) radiographs illustrating fragment-specific fixation of this fracture with restoration of carpal alignment. Copyright 2013 by Scott W. Wolfe, MD. For permission to reuse contact wolfes@hss.edu. Adaptations are themselves works protected by copyright. So in order to publish this adaptation, authorization must be obtained both from the owner of the copyright in the original work and from the owner of copyright in the translation or adaptation.

"Augmented" external fixation refers to the use of percutaneous K-wires and, when necessary, subarticular bone grafting to supplement an external fixator.[49,50] This form of fixation has been shown to produce excellent clinical results, and some authors prefer to use this method routinely.[51–54] Although relatively straightforward to apply, the increased pin-care demands and the bulkiness of external devices makes this technique less desirable for patients.

Distraction plating with an internal bridge plate, as originally described by Burke and Singer,[55] may be used in complex fractures with or without percutaneous K-wires and subarticular bone grafting. This technique has been successful in cases of severe, unreconsructable comminution of the articular surface or significant metaphyseal or diaphyseal comminution.[56,57] In athletes, bone quality is typically sufficient to allow anatomic reduction of articular fractures; however, some athletes sustain high-energy severely comminuted articular distal radius fractures, with attendant metaphyseal or diaphyseal comminution, and may require this technique for fixation.

Choice of Fixation

When determining what fixation to use, we prefer to use the classification described by Fernandez,[58] which characterizes fractures based on the mechanism of injury

FIGURE 6. Posteroanterior (A) and facet lateral (B) radiographs of a type III distal radius fracture with a large volar fragment and dorsal ulnar corner fracture. This fracture was treated with a locked volar plate and dorsal fragment-specific fixation. Posteroanterior (C) and facet lateral (D) radiographs at 8 weeks postoperatively showing maintenance of volar tilt and carpal alignment. Copyright 2013 by Scott W. Wolfe, MD. For permission to reuse contact wolfes@hss.edu. Adaptations are themselves works protected by copyright. So in order to publish this adaptation, authorization must be obtained both from the owner of the copyright in the original work and from the owner of copyright in the translation or adaptation.

(Fig. 1). This classification can be readily determined on standard anteroposterior, oblique, and facet lateral radiographs. The mechanism of injury; the presence of concomitant injuries; and the patient's activity level, age, handedness, expectations, and goals influence operative decision-making. Patients may also have preferences of external versus internal fixation, volar versus dorsal incisions, or surgery versus a trial of closed treatment. We prefer to choose fixation strategies based on fracture pattern, while remaining cognizant of patients' preferences.

Unstable, nonarticular bending fractures (type I) can be successfully treated with any number of fixation strategies. Care must be taken to exclude the presence of a volar ulnar or a dorsal ulnar separate articular fragment. The facet lateral should be closely inspected to identify these fragments or clues that these fragments are present. If a volar or dorsal fragment exists or is suspected, we have a low threshold to obtain a computed tomography scan to further evaluate the fracture pattern.

When a truly isolated nonarticular bending fracture is present, we prefer to utilize locked volar plating through a standard volar Henry approach (Fig. 2). We especially advocate this choice of fixation in cases of late presentation, which necessitates removal of abundant callus, or in cases of osteoporosis. In the later population, locked volar plating prevents secondary loss of reduction.[59] We prefer locked volar plating over dorsal plating because of concerns about extensor tendon irritation and subsequent hardware removal associated with dorsal fixation.[60–62] In the absence of volar or dorsal corner fractures, fragment-specific fixation is unnecessary and volar plate fixation results in superior outcomes in this cohort.[63]

For volar shear fractures (type II), particular attention should be directed toward the extent of the volar surface involved. Some shear fractures include only the scaphoid facet, but others extend across the entire volar lip into the sigmoid notch. The ulnar corner of the volar cortex is the volar half of the lunate facet and acts as the primary restraint to volar subluxation of the carpus. It also is the volar rim of the sigmoid notch and an important stabilizer of the DRUJ. It is imperative that surgeons address this fragment, if present, to prevent postoperative volar subluxation of the carpus and DRUJ instability (Fig. 3).

If only a single large volar fragment is present, we prefer a locked volar plate through the standard volar Henry approach for the same reasons we prefer this fixation for type I fractures. However, if there is a small, unstable volar ulnar fragment present, we prefer fragment-specific fixation, particularly if the injury is associated with lunate subluxation. A standard locked volar plate often does not capture the volar ulnar fragment, and sliding the locked plate distal enough to capture the fragment results in flexor tendon irritation or rupture.[64] With fragment-specific fixation, we can obtain reliable reduction and fixation of the volar lip and sigmoid notch.[42–48] Isolated dorsal shear fractures are rare injuries. We prefer to treat these injuries with both a dorsal and radial column plate (Fig. 4), because it is biomechanically superior to either a dorsal plate alone or a volar plate with or without a radial styloid plate.[65] This is especially true if a large radial styloid fragment is present.

Radial styloid shear fractures (chauffeur's fracture) are often associated with concomitant scapholunate ligament disruption, making these fractures our prime indication for arthroscopically assisted reduction,[66] which has been shown in several studies to lead to superior outcomes in articular distal radius fractures.[67–70] We prefer a radial column pin plate or 2.0 mm fixed angle plate through a radial column approach for fixation of these fractures.

Compression fractures of the joint surface (type III) may result in simple patterns with only 2 fragments or complex patterns with many fragments. Volar or dorsal ulnar corner fractures are often seen in these types of fractures; therefore, we prefer to treat these with a fragment-specific fixation for the same reasons discussed previously (Fig. 5). The radial column is approached first and provisionally reduced and pinned. The dorsal or volar ulnar fragment is then approach through a limited dorsal or volar approach and stabilized with pin plates. Finally, the radial column is fixed with a pin plate or fixed angle plate, if necessary.

In cases of significant comminution in type III fractures, a computed tomography scan is routinely obtained to delineate the fracture fragments and plan fixation. A volar locking plate alone does not adequately stabilize the dorsal rim, the dorsal ulnar corner, and the central articular fragments in these fracture patterns. Dorsal fixation alone, similarly, cannot address the volar ulnar fragment or volar lip. We, thus, prefer to treat these complex fractures with a fragment-specific approach, which allows the surgeon the flexibility to adequately address all aspects of the fracture. If the volar component is large enough, we prefer to treat these fractures with a combination of a locked volar plate and fragment-specific fixation (Fig. 6). If this dorsal ulnar fragment is not addressed, dorsal subluxation of the carpus may occur.

Treatment of radiocarpal fracture dislocations (type IV) is beyond the scope of this article, but management of the fractured components in these injuries generally follows the principles outlined above. Treatment of combined/high-energy injuries (type V) is tailored to the specific fracture pattern. If the fracture is amenable, a long metadiaphyseal fixed angle device optimally restores radial alignment and bridges metaphyseal comminution. External fixation, distraction plating, bone grafting, fragment-specific fixation, and any combination of these techniques are used to treat this heterogenous fracture pattern.

CONCLUSIONS

Sports-related distal radius fractures occur in a unique population compared with the classic fragility fracture seen in the elderly. Treatment strategies should nonetheless follow sound orthopedic principles, and pressure to return to sport should not alter the surgeon's decision-making. Although it is acceptable to treat many unstable distal radius fractures with a volar locking plate, the key to successful surgical management of these injuries is to recognize when a volar locking plate will not provide sufficient fixation. A fixation strategy tailored to the specific fracture pattern will lead to optimum functional outcome and return to sport.

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