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Athletic Injuries of the Wrist and Hand

Part I: Traumatic Injuries of the Wrist

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Hand and wrist injuries in sports are some of the most common injuries reported. This review discusses briefly the causes of hand and wrist injuries in sports and discusses pertinent biomechanical findings regarding the range of motion required in different sports activities. The bulk of the review discusses specific traumatic and overuse injuries to the hand and wrist commonly seen in the athlete. Emphasis is placed on problematic traumatic injuries such as carpal scaphoid fractures and hook of the hamate fractures, as well as ligament injuries to the wrist with regard to diagnosis, treatment, and return to athletic competition.

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Hand and wrist injuries are common occurrences in all sports. A review of the literature reveals that 3% to 9% of all athletic injuries involve the hand and wrist.10,27,55,82 Hand and wrist injuries may be divided into two major classifications, traumatic and overuse. Traumatic injuries include fractures, dislocations, and ligament tears often seen in contact/collision sports; stress and overuse conditions are seen in gymnastics, racquet sports, and golf. The majority of injuries in a primary care setting are soft tissue injuries (sprains, strains, and contusions). In tertiary referral centers, fractures of the hand and wrist are more common.

In a 10-year study of all injuries at the Olympic Training Center (Colorado Springs, Colorado), 8.7% (729 of 8311 total injuries) involved the wrist and hand. The majority of these injuries were sprains and contusions (64%). In collision sports, such as football, hand and wrist injuries account for 15% of all injuries. These data are based on a study presented by the National Athletic Trainers Association (unpublished data, 1986) of high school injuries and the incidents recorded on an NFL team (A. Rettig, unpublished data, 1989 to 1993). The incidence of wrist problems is much higher in sports such as gymnastics, ranging from 46% to 87% of participants.19 Many injuries are sport-specific, such as stress fractures of the hook of the hamate in golf, tennis, and baseball; Guyon’s canal syndrome (cyclist’s palsy) in cycling; distal physeal injuries in gymnastics; and ulnar wrist pain in racquet sports.

BIOMECHANICS OF THE WRIST IN SPORTS

The wrist functions to position the hand in space for gripping and grasping activities. This is accomplished mechanically by a unique and complex arrangement of bony and ligamentous structures.

Using electrogoniometric studies, Ryu et al.90 have shown that most daily activities can be performed with 40° of wrist extension, 40° of flexion, and a 40° arc of radial and ulnar deviation. Wrist range of motion required for performance in various sports has been calculated by using the triaxial electrogoniometric technique. Free throw shooting in basketball requires an average of 50° of extension (range, 40° to 56°) and 70° of flexion (range, 48° to 84°) for an arc of 120° in the shooting hand. The nondominant wrist required only an arc of 32° of flexion/extension and 16° of radial-ulnar deviation in the activity. This has implications when considering certain motion-limiting reconstructive procedures in the wrist of a basketball player.

Pappas et al.76 studied wrist range of motion in baseball pitchers, including the cocking, acceleration, deceleration, and recovery phases of throwing. During the cocking phase, the wrist extends from neutral to 32° of extension, followed by rapid flexion over 94° during the 105 msec of the acceleration phase. Wrist flexion is important in the throwing athlete.

The golf swing in right-handed golfers has also been studied and reveals that an arc of 103° of flexion/extension is required in the right wrist as opposed to 71° in the left (J. Y. Ryu, unpublished data, 1990). It is noteworthy that 45° of radial-ulnar excursion is required in both wrists. Advanced players use less flexion/extension on the left, but more on the right, than those with high handicaps.
These studies have implications for wrist splinting as there is great variability between sports and positions regarding the ability of athletes to participate with limited wrist motion.

TRAUMATIC INJURIES

Carpal Scaphoid Fractures

The most common, and also the most problematic, fracture in the wrist of athletes is that of the carpal scaphoid. It accounts for 70% of all carpal fractures and is most prevalent in the 15- to 30-year-old population. The scaphoid bone has an irregular shape, and 80% of the surface is covered by articular cartilage. Blood supply to the scaphoid has been well documented by Panagis et al., who have shown that dorsal vessels supply 70% to 80% of vascularity, the majority of which enters at the dorsal ridge of the scaphoid (Fig. 1). Because of the vascular anatomy, proximal pole fractures have a worse prognosis for healing than more distal injuries.

The biomechanics of the scaphoid fracture have been well defined by Weber and Chao, who reproduced the fracture in the laboratory in wrists in more than 90° of dorsiflexion and more than 10° of radial deviation and with more than 400 kg of force. Distal radius fractures occur with less dorsiflexion and with less load.

The diagnosis of acute scaphoid fracture is sometimes difficult because initial plain radiographs frequently do not show the fracture. Any contact-sport athlete who has radial wrist pain should be considered to have a scaphoid fracture until proven otherwise. Physical examination in the acute setting reveals tenderness in the “anatomic snuffbox,” decreased range of motion, swelling, and pain with dorsiflexion.

In cases of clinical suspicion of scaphoid fracture that are not shown radiographically, other imaging studies are indicated. My colleagues and I prefer to obtain MRI studies to determine the presence or absence of a fracture. Other studies such as bone scan and CT are helpful, but bear in mind that false-negative studies have been reported (Fig. 2).

Scaphoid fractures are classified by location, stability, and time from injury. Most acute fractures in the athlete are mid-third and minimally displaced, although unstable and mid-third proximal pole fractures are not uncommon.

The goal of treatment of acute scaphoid fracture is to obtain union. Natural history studies of untreated scaphoid fractures demonstrate that fracture nonunion and progressive radial carpal arthrosis ensue, with severity increasing with time from injury. Kerluke and McCabe noted that these studies are retrospective and that a true prospective study has not been done.

Treatment of acute scaphoid fracture in the athlete depends on location and stability of the fracture, sport and position, and desires of the athlete and his or her family. Options include 1) cast treatment with no sports participation until healed, 2) cast treatment plus use of a playing cast/splint in sports where applicable, and 3) internal fixation of the fracture with return to play as symptoms permit.

Cooney et al. have shown that 90% to 100% of mid-third fractures will heal with cast treatment if treatment is started in the first 3 weeks after injury. The average healing time in these cases is 8 to 10 weeks. Application of a Muenster-type or long arm cast for 4 weeks, followed by a short arm cast, is the traditional method of treatment. The athlete must be prepared to miss a minimum of 3 months of sports participation with this treatment.

An alternative to casting is the use of a short arm thumb spica splint during nonathletic activities and a playing cast to allow participation in sports where this is allowed, such as football and soccer. Reister et al. and Rettig et al. reported a 90% union rate using this method. Reondo and Rehak (unpublished data, 1996) more recently compared union rates with traditional casting and no participation, versus casting plus playing cast. They noted an increased nonunion rate in the playing cast group and that 39% of athletes with a playing cast required surgery to obtain union, versus 15% in the cast-only group.

The third treatment option is to proceed with open reduction and internal fixation of the fracture. Some authors agree that open reduction and internal fixation is indicated for unstable fractures and proximal pole fractures.

Treatment of minimally displaced or nondisplaced mid-third fractures is more controversial. This type of fracture is amenable to limited incision (mini-open) internal fixation or percutaneous internal fixation. Inoue and Shionoya compared cast treatment with mini-open internal fixation in workers and noted that time to work averaged 10.2 weeks in the cast group and 5.8 weeks in the internal fixation group, with nearly 100% union in both groups.

Figure 1. A cleared specimen showing the internal vascularity of the scaphoid. The vessels in the dorsal and volar scapholunate ligaments do not penetrate the bone. 1, dorsal scaphoid branch of the radial artery; 2, volar scaphoid branch. (Reprinted with permission from Rettig AC: Management of acute scaphoid fractures. Hand Clin 16: 381–395, 2000.)
Return to sports after use of an open Rüssel approach was found to be 5.8 weeks, versus 4.4 weeks with a limited incision approach (Rettig and Puckett, unpublished data, 1995). Use of a cannulated Herbert-Whipple 3.0 synthetic compression screw with threaded washer and, more recently, percutaneous fixation by Acutrak screw (Acumed, LLC, Hillsboro, Oregon) (J. Slade, unpublished data, 2003) have been advocated. Although internal fixation of acute scaphoid fractures is still controversial, it has become more accepted as the standard of treatment for this difficult problem.

Scaphoid fractures with delayed or no union are frequently seen in athletes because the initial injury is often ignored. Frequently, a football player is seen at season's end with a painful wrist and an established nonunion. Symptomatic nonunion fractures should undergo bone grafting and internal fixation, but return to play must be delayed until healing occurs. The standard procedure consists of an iliac crest bone graft. More recently, vascularized bone graft from the distal radius has been shown to result in accelerated healing. Use of electrical stimulation to aid in healing is controversial.

Controversy also exists regarding the treatment of asymptomatic nonunion of these fractures. On the basis of previously noted natural history studies, some physicians advocate bone grafting and internal fixation. Participation in sports at a high level with nonunion of scaphoid fractures has been shown by Shields (unpublished data, 1982); the option of treatment must be discussed with the athlete and his or her family.

Hook of the Hamate Fractures

Fractures of the body of the hamate may occur from trauma and usually occur in combination with fractures of the base of the fourth and fifth metacarpals. Fractures of the hook of the hamate are more common in athletes.

The incidence of hook of the hamate fractures is 2% to 4% of all carpal fractures. The mechanism of injury is thought to be caused by abutment of the hook on an object or by a shearing force applied by the flexor tendon of the small and ring fingers. The injury usually occurs in athletes who participate in baseball, golf, and racquet sports because of the position of the implement in the hand (Fig. 4). Fracture anatomy has been studied; of note is a watershed area that may explain the high incidence of nonunion post fractures.

Hook of the hamate fracture must be suspected in ath-
letes participating in racquet sports, golf, or baseball who are seen with ulnar wrist pain. Examination reveals tenderness over the hook of the hamate, which lies on a line between the pisiform and second metacarpal head. Plain radiographs usually do not reveal the fracture; carpal tunnel and supinated oblique views should be obtained. Diagnosis is confirmed by CT scan and bone scan.

Treatment of hook of the hamate fractures in athletes varies from casting to open reduction and internal fixation to excision. Bishop and Beckenbaugh reported 21 cases of this fracture, 17 were treated by excision, 3 underwent open reduction and internal fixation, and 1 had casting. Although two of three fractures that were treated with open reduction and internal fixation healed, many authors recommend excision, which has an average return to sport of 7 to 10 weeks.

Lunate Fractures

Acute fracture of the lunate is rare; however, athletes may be seen with Kienböck’s disease or avascular necrosis of the lunate, presumably due to repetitive trauma. Such athletes usually have insidious onset of fracture, although a single traumatic event may be recalled.

Physical findings of these fractures include tenderness in the lunate or at the radial carpal area, decreased range of motion, and decreased grip strength. Plain radiographs may be negative in the early stages, and MRI is needed for a definitive diagnosis. The condition is usually associated with an ulnar negative variance on posteroanterior radiographs.

Treatment of Kienböck’s disease is complex and depends on the stage of the disease. In stage 0 to 2A of the disease, where there is minimal carpal collapse, joint-leveling procedures (such as radial shortening) is compatible with return to sports. Intercarpal arthrodesis or proximal row carpectomy should be reserved for salvage cases and will result in significant limitation of wrist motion.

Pisiform Fractures

The pisiform bone may be injured from a direct blow and it can undergo chondral changes from overuse, leading to pisotriquetral arthrosis. This is frequently seen in athletes who participate in racquet sports. Diagnosis may be made by injection of lidocaine at the pisotriquetral articulation. In cases of pisotriquetral fractures, excision of the pisiform may be indicated, with return to sports in 6 to 8 weeks.

LIGAMENT INJURIES OF THE WRIST

Stability of the wrist depends on the geometry of the individual carpal bones and the ligamentous interconnections that control movement of one bone on another. The most common instabilities involve injury to the intrinsic ligaments of the wrist, mainly those that connect the scaphoid and lunate, and lunate and triquetrum bones. A less common type of instability (midcarpal instability) results from injury or attenuation of the ligaments connecting the proximal and distal carpal rows.

The scaphoid exerts a flexion moment on the proximal
row and the triquetrum exerts an extension moment. The lunate is held in neutral alignment by the scapholunate and lunotriquetral ligaments. If one of these ligaments is disrupted, abnormal carpal alignment and mechanics result. The disruption may be partial or complete, with the former resulting in dynamic carpal instability, which can be demonstrated in stress radiographic views or cine studies, and the latter resulting in static deformity, in which resting radiographs reveal the abnormalities.

SCAPHOLUNATE INJURIES

Scapholunate injuries, the most common type of wrist ligament injury, results from excessive wrist extension and ulnar deviation with intercarpal supination, such as a fall on a pronated hand.83 Injury to the scapholunate ligament may be partial or complete, depending on the force involved. The injury is common in collision and contact sports or any activity where a fall may occur.

After scapholunate ligament disruption, the scaphoid assumes a flexed position and the lunate and triquetrum extend, producing a dorsal intercalated segment instability pattern.25,69 Wrist motion and load-bearing capacity may be compromised after such an injury, and pain occurs secondary to abnormal cartilage loading (shear) and synovitis. Over time, progressive arthrosis may ensue after scapholunate dissociation, with advanced collapse.

The diagnosis of the scapholunate ligament injury in the acute setting depends on obtaining an accurate history (the inciting incident is usually a fall or injury from jamming into another athlete), precise physical examination, and appropriate imaging studies.

In acute injuries, there is usually significant swelling, decreased range of motion, and tenderness, most marked in the scapholunate area and on the dorsal aspect of the wrist. The scaphoid shift test (Watson’s sign 104i) is performed by applying a dorsal load to the distal pole of the scaphoid as the wrist is moved from an ulnar to radial deviation. Reproduction of pain and hearing a “pop” constitutes a positive test (Fig. 6). This test frequently is not possible to perform in the acute setting because of inflammation and pain; it is more reliable in chronic cases. The examination findings should always be compared with the opposite wrist as many athletes have a physiologically positive scaphoid shift test.

Imaging studies may be positive in acute and complete injuries, demonstrating a gap of more than 2 to 3 mm on the posteroanterior views and an increased scapholunate angle on the lateral radiograph. Stress views, such as a clenched fist view and supinated view in ulnar deviation, are helpful. All radiographs must be compared with those of the uninjured wrist.

Additional imaging studies such as arthrography or MRI may be obtained but have variable sensitivity and specificity regarding intercarpal ligament tears.53,64,86,92,93 Although complete scapholunate tears can usually be diagnosed by these studies, incomplete tears present a more difficult problem. Wrist arthroscopy is now the standard method of diagnosing intercarpal ligament injuries.

Treatment of acute and complete scapholunate ligament injuries involves arthroscopy of the wrist to confirm the diagnosis and open repair of the scapholunate ligament with or without augmentation. Nathan and Blatt68 described a dorsal capsulodesis as augmentation (Fig. 7), but this results in some decrease in palmar flexion, which is undesirable in many athletes. Berger (unpublished data, 2003) has proposed using a portion of the dorsal intercarpal ligament, which runs from the triquetrum to the distal scaphoid, for repair of this injury. The ligament is detached from the triquetrum and attached to the lunate by a suture anchor to augment the repair. Theoretically, this results in more normal range of motion. It is important for the athlete to have a stable, pain-free wrist with near-normal range of motion and grip strength after repair.

In scapholunate ligament injuries that are not complete, arthroscopic evaluation with percutaneous pin fixation has been advocated.109 More recently, Geisler and Savoie (unpublished data, 2003) have described thermal shrinkage of partial tears with or without pin fixation. Long-term results of this procedure are not available yet.

Scapholunate ligament injuries are commonly chronic problems. Treatment of these cases is much more challenging. Primary repair may be performed up to 6 to 9 months after injury in certain situations. Berger (unpublished data, 2003) has described a bone-ligament-bone reconstruction for chronic cases using capitate-hamate bone plugs, similar to patellar tendon grafts for ACL reconstruction. Results of this procedure and others are somewhat unpredictable, but promising.

In more chronic cases, where anatomic reduction cannot
be obtained, a partial wrist arthrodesis such as a scapho-
capitate or scapho-trapezio-trapezoid fusion may be per-
formed, although this results in approximately 35% de-
creased range of motion, which is compatible with adequate
performance in many sports. If arthrosis is present, a sal-
vage procedure such as proximal row carpectomy or
scapholunate dissociation with advanced collapse wrist
reconstruction may be indicated.

LUNOTRIQUETRAL INJURIES

Lunotriquetral injuries are usually the result of a sudden
axial load with wrist extension and radial deviation with
intercarpal pronation as opposed to supination, as in the
scapholunate tears. These tears are much less common
than scapholunate injuries (approximately 1:698), and the
lunotriquetral ligament is much thinner than the
scapholunate ligament.

Although complete scapholunate disruption frequently
leads to static dorsal intercalated segment instability de-
formity, lunotriquetral tears are rarely seen as a volar
intercalated segment instability pattern because of the
presence of secondary stabilizers. Dorsal and volar
extrinsic ulnar carpal and volar carpal ligaments help
maintain the resting orientation of the triquetrum and
lunate.

The athlete with a lunotriquetral injury usually gives a
history of a fall on an outstretched hand and resultant ulnar-
sided wrist pain, weakness, giving way, and a click sound
with loading. Examination reveals tenderness over the
lunotriquetral ligament and includes provocative tests such
as a lunotriquetral shear test. This test involves applying
a dorsally directed force over the pisiform (triquetrum) and a
palmar-directed force on the lunate, which produces a click
and reproduces the patient’s pain (Fig. 8).

In diagnosis of lunotriquetral injuries, plain radio-
graphs are usually normal, although occasionally a step-
off may be noted along the proximal carpal row. Wrist
arthrography has a variable sensitivity, and it has

Figure 7. Capsulodesis as augmentation for complete scapholunate ligament injury. A, intraoperative photograph depicting
scapholunate ligament disruption in which the ligament has avulsed off the lunate; B, after Kirshner wire stabilization of the
reduced scapholunate relationship, the ligament has been repaired; C, diagram depicts a dorsal capsulodesis, securing the
dorsal wrist capsule to the distal pole of the scaphoid. (Reprinted with permission from Cohen MS: Ligamentous injuries of the

Figure 8. Depiction of the provocative lunotriquetral shear
test used to detect lunotriquetral ligament insufficiency. Dor-
sal pressure is applied to the lunate, with corresponding
palmar pressure on the triquetrum. This creates a shear
vector on the lunotriquetral joint. A painful click with instability
is diagnostic of lunotriquetral dissociation. (Reprinted with
permission from Cohen MS: Ligamentous injuries of the wrist
been shown in cadaveric studies that 20% of asymptomatic persons between 20 and 60 years of age have a positive arthrogram. Magnetic resonance imaging is unpredictable as the ligament is quite small and the signal is difficult to interpret. If symptoms persist after immobilization, wrist arthroscopy remains the most definitive diagnostic tool.

Lunotriquetral injuries, as opposed to scapholunate tears, usually do not lead to progressive arthrosis. In acute lunotriquetral injuries, immobilization is the initial treatment of choice and may lead to ligament healing in 80% of cases. In cases of persistent symptoms that do not respond to activity modification or nonsteroidal anti-inflammatory drugs with or without steroid injection, surgical options vary from simple arthroscopic lunotriquetral ligament debridement to lunotriquetral arthrodesis—which has a significant nonunion rate and results in 20% to 30% loss of range of motion to ulnar-shortening osteotomy. Ulnocarpal forces are significantly reduced (20% to 4% with 2 mm of shortening) after ulnar shortening and tension on the ulnar carpal ligament complex is increased, thus aiding in stabilization of the lunotriquetral joint. Also, return to sports after arthroscopic debridement is 6 to 8 weeks, whereas ulnar shortening may require 3 to 6 months.

MIDCARPAL INSTABILITY

Midcarpal instability is a form of carpal instability nondissociative, which means that the relationship within each carpal row is intact and the lesion occurs between the carpal rows. The lesion is thought to be caused by attenuation of the ulnar V ligament connecting the capitate with the distal carpal row to the triquetrum of the proximal row.

Patients with this instability have ulnar wrist pain, and there is a painful “clunk” sound with ulnar deviation. Normally, the proximal carpal row moves from a flexed position in radial deviation to an extended position in ulnar deviation in a smooth transition. In midcarpal instability, the proximal row stays flexed until late in ulnar deviation and then “snaps” audibly into dorsiflexion, a situation known as the “catch-up clunk.”

On physical examination, a sulcus may be noted in the dorsal ulnar border of the wrist and a catch-up clunk may be demonstrated by simply having the athlete actively deviate the wrist ulnarly. The clunk is neutralized by applying dorsal-directed pressure over the pisiform and ulnar carpus. This maneuver helps confirm the diagnosis. The condition is frequently bilateral and the opposite wrist must be tested.

Plain radiographs may demonstrate a volar intercalated segment instability pattern because of the palmar-flexed proximal row. Cinefluoroscopic examination of the wrist is the most helpful tool in confirming the diagnosis. Treatment of midcarpal instability is controversial. Frequently, athletes with midcarpal instability will respond to activity modifications, splinting, nonsteroidal anti-inflammatory drugs, and will be able to return to sport.

The use of a splint that supports the volar ulnar carpus (Fig. 9) may be helpful for participation in some sports, especially racquet sports. If the athlete cannot participate and continues to be symptomatic, surgical options are unpredictable. A recent development involves the use of thermal shrinkage or modification of the V ligament arthroscopically. This is an attractive option, although long-term results are unknown. Reconstruction and midcarpal arthrodesis are last-resort procedures that are of questionable benefit to the athlete.

DISLOCATION OF THE CARPUS

Perilunate dislocation or volar lunate dislocation of the wrist results from excessive radiocarpal hyperextension and ulnar deviation plus intercarpal supination. Mayfield has described various stages of progressive injury; the previously discussed scapholunate dissociation is stage I. Perilunate dislocation results from disruption of the scapholunate and lunotriquetral ligaments, plus radial collateral ligament failure, and by rupture of the capitohamate capsule (Fig. 10).

Perilunate dislocation should be suspected after trauma in collision sports when significant swelling and significant decreased range of motion are observed. Minor swelling and deformity may not be that noticeable. The examiner should check neurocirculatory function as carpal tunnel syndrome with compression of the median nerve is frequently a complication of the injury.

The diagnosis is readily made on a true lateral radiograph in which the capitate is dorsally displaced on the lunate. In volar lunate dislocation, the lunate is displaced volarly into the carpal tunnel.

Treatment of perilunate/volar lunate dislocations range from closed reduction with percutaneous pinning to open reduction, repair, and internal fixation using a dorsal or dorsal and volar combined approach. The standard surgical approach of perilunate/volar lunate dislocations is open reduction and repair of ligament structures and pin fixation stabilizing the scapholunate and lunotriquetral articulations. If there is...
median nerve compromise, dorsal and volar approach with decompression of the nerve and repair of the volar capsule structures is desirable.

Raab et al.79 reviewed 10 cases of perilunate dislocation in the National Football League, 6 of which were treated by closed reduction and percutaneous pin fixation. Nine of the 10 athletes returned to play, and 5 returned during the same season as injury, between 3 and 8 weeks after the injury. In certain cases, percutaneous pin fixation after closed reduction is a viable option in the athlete, although long-term results are questionable.

DISTAL RADIOUNLAR JOINT AND TRIANGULAR FIBROCARTILAGE COMPLEX INJURIES

Distal radioular joint and triangular fibrocartilage complex injuries are common in athletes and may be the result of acute trauma, traumatic injury such as a fall or overuse, or repetitive trauma such as results from participation in racquet sports. The triangular fibrocartilage complex is generally regarded as the primary stabilizer of the distal radioular joint.73 The triangular fibrocartilage complex is divided into a central articular disc portion, which is relatively avascular, and the dorsal and palmar radioulnar ligaments, which are more vascular and are stabilizing structures of the distal radioulnar joint (Figs. 11 and 12). The volar ulnar carpal ligaments extend from the periphery of the triangular fibrocartilage complex and ulnar styloid to the lunate and triquetrum. The triangular fibrocartilage complex is completed by the ulnar extensor muscle subsheath and the ulnar collateral ligament.74

The axially loaded forearm bears 82% of the load through the radius and 18% through the triangular fibrocartilage complex and ulna.72 The thickness of the triangular fibrocartilage complex varies inversely with a positive ulnar variance, and it has been shown that increased positive ulnar variance results in increased load-bearing through the ulnar axis.72 Injuries to the triangular fibrocartilage complex are more common in the wrist with ulnar positive variance.

The diagnosis of triangular fibrocartilage complex injury depends on a careful history of injury and whether a single traumatic event is implicated or there is an insidious onset. Triangular fibrocartilage complex injury must be differentiated from other causes of ulnar wrist pain such as lunotriquetral injuries (described earlier), ulnar extensor muscle tendinitis or subluxation, chondral lesions of the distal radioular joint, ulnar flexor muscle tendinitis/pisotriquetral compression syndrome, and ulnar carpal impingement. Palmer and Werner72 have classified triangular fibrocartilage complex tears into trau-

Figure 10. The four stages of progressive perilunate instability resulting from sequential disruption of key ligament structures in the vulnerable perilunar zone. Stage I is characterized by scapholunate dissociation, stages II and III by perilunate dislocation, and stage IV by complete destabilization with volar dislocation of the lunate. (Reprinted with permission from Melone CP Jr, Murphy MS, Raskin KB: Perilunate injuries. Repair by dual dorsal and volar approaches. Hand Clin 16: 439–448, 2000.)

Figure 11. End-on view of the distal radius (R) and triangular fibrocartilage complex (TFC) after india ink injection. The radioulnar ligaments and peripheral 15% to 20% of the articular disc are well vascularized. No vessels have been identified in the central area of the articular disc. (Reprinted with permission from Dailey SW, Palmer AK: The role of arthroscopy in the evaluation and treatment of triangular fibrocartilage complex injuries in athletes. Hand Clin 16: 461–476, 2000.)
matic and degenerative. Traumatic tears, usually noted in young athletes, may be central or peripheral, and peripheral tears may result in distal radioulnar joint instability.

Acute traumatic events involve axial load-bearing with rotational stress, usually due to a fall on the outstretched hand. Acute injuries may be superimposed on chronic repetitive traumatic events. Triangular fibrocartilage complex injury and ulnar wrist pain are common in gymnasts, racquet players, hockey (from impact with the boards in slap shots, peripheral tears may result in distal radioulnar joint instability. The trampoline test involves probing the triangular fibrocartilage complex to assess the tension. If normal bounce is not present, a peripheral triangular fibrocartilage complex tear may exist.

The physician treating high-level athletes—elite high school, collegiate, or professional athletes—may consider a more aggressive approach to the patient with suspected triangular fibrocartilage complex/distal radioulnar joint injury. If distal radioulnar joint instability is demonstrated, early intervention with arthroscopy and peripheral triangular fibrocartilage complex repair is indicated. If the distal radioulnar joint is stable and symptoms are present for 2 to 3 weeks, arthroscopy is also indicated.

In stable distal radioulnar joint injuries with type 1A triangular fibrocartilage complex tears (traumatic tears of the central articular disc), debridement of the centrum has been well documented as the treatment of choice. Postoperatively, patients with debrided central lesions are splinted for 1 week and range of motion is begun. Golf or tennis athletes may begin light-activity ball contact at 3 weeks and are typically able to return to restricted sports activity in 4 to 6 weeks. There have been 90% good-to-excellent results with debridement of the centrum reported by Bednar and Osterman.

For type 1B lesions (peripheral triangular fibrocartilage complex tears at the ulnar insertion), a more aggressive approach, as opposed to immobilization, is recommended for athletes. Arthroscopic repair may be performed by one of several techniques. Postoperatively, the repair is protected in a Muenster cast for 6 weeks, followed by active range of motion. Strengthening is begun at 8 weeks and return to sport occurs in 3 to 4 months. More than 90% good-to-excellent results have been reported with this treatment.

In degenerative triangular fibrocartilage complex lesions or acute or chronic injuries, the ulnar variance must be carefully assessed. In neutral and positive variance, the option of ulnar shortening, either by a Feldon wafer resection or formal ulnar shortening with plate fixation,
should be discussed with the athlete. The Feldon wafer technique is indicated in cases of an ulnar variance of less than 3 mm and may be performed open or arthroscopically.\(^3\) In cases with more than 3-mm positive variance, a formal open ulnar shortening with 3.5 compression plate fixation is indicated, accompanied by wrist arthroscopy. Midcarpal arthroscopy should be performed in all cases to evaluate the proximal pole of the hamate for possible chondral lesions, which are seen in athletes with type 2 lunate bones in which a facet on the lunate articulates with the triquetrum.\(^3\) In cases with more than 3 mm and may be performed open or arthroscopically. In cases with more than 3-mm positive variance, a formal open ulnar shortening with 3.5 compression plate fixation is indicated, accompanied by wrist arthroscopy. Midcarpal arthroscopy should be performed in all cases to evaluate the proximal pole of the hamate for possible chondral lesions, which are seen in athletes with type 2 lunate bones in which a facet on the lunate articulates with the triquetrum.

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