Middorsal Wrist Pain in the High-Level Athlete

Causes, Treatment, and Early Return to Play

Zachary C. Hanson,*† MD, and Gary M. Lourie,†‡ MD

Investigation performed at The Hand & Upper Extremity Center of Georgia, Atlanta, Georgia, USA

Wrist injuries in the competitive athlete are a common reason for evaluation related to an acute injury or after symptoms have become chronic. While radius- and ulna-sided wrist pain are common topics covered in the literature, middorsal wrist pain is more common than the available literature would suggest. Missed diagnoses and inadequate treatment can significantly increase athlete morbidity and delay return to play. The goal of this article was to review the differential diagnosis of middorsal wrist pain in the athlete and discuss the diagnosis, treatment, and early return to play for each condition.

Keywords: wrist; dorsal wrist pain; overuse; athletic injuries; dorsal wrist impingement; dorsal wrist syndrome

Wrist injuries in the competitive athlete are a common reason for referral to the orthopaedic surgeon. Often due to an isolated acute injury, wrist injuries are not uncommonly evaluated as a chronic, persistent source of dysfunction. Most publications have devoted attention to the ulnar and radial wrist. In a PubMed literature search for papers published in the past 10 years on "wrist pain in athletes," we found 250 entries on ulna-sided wrist pain, 30 devoted to the radial side, and <5 publications discussing middorsal injury. While underrepresented in the literature, middorsal wrist injuries in the athlete are more common than previously thought. Missed diagnoses and inadequate treatment can significantly increase athlete morbidity and delay return to play. The goal of this article was to review the differential diagnosis of middorsal wrist pain in the athlete (Table 1). Each section is presented systematically and includes a review-pertinent clinical anatomy, history, physical findings, diagnostic imaging, treatment, and early return to play with minimal risk. The senior author (G.M.L.) has adopted a useful acronym, "APPLES," to guide in the clinician's decision to allow return to play: *A*, age; *P*, position; *PL*, performance level; *E*, enhancement drug usage; and *S*, season, to identify in- or out-of-season date of injury. By assessing the injury and the athlete, we have been able to make easier the decision if and when all the players can return to play, minimizing the risk and avoiding long-term complications.[37]

TRAUMATIC AND OVERUSE INJURIES

Scapholunate Ligament Injuries

The scapholunate interosseous ligament (SLIL) is a stout interosseous structure connecting the scaphoid and lunate and is the primary stabilizer of proper intercarpal alignment, providing normal wrist kinematics and force transmission across the carpus.[43] SLIL injuries represent the most common form of carpal instability.[30,47] Left untreated, SLIL injuries lead to dorsal intercalated segment instability deformity, progressive carpal collapse, and radiocarpal degeneration.[53-55] This predictable pattern of degeneration is termed scapholunate advanced collapse and can be incapacitating, emphasizing the need for early diagnosis. Injury to the SLIL occurs after a fall with the wrist extended and ulnarly deviated, causing excessive midcarpal supination and subsequent tearing of the SLIL.

Pain is localized dorsally over the joint capsule and scapholunate (SL) interval, usually located 1 cm distal to the Lister tubercle. Patients often have concerns of grip weakness, swelling, and a painful click.[30,51] Reproduction of painful clicking or grinding when the wrist is axially loaded is specific for injuries involving the SL complex and is a helpful clue, particularly in athletes who may notice pain during push-ups or military press.[2,65] The Watson scaphoid shift test and SL ballottement tests are provocative maneuvers used to detect excessive motion of the scaphoid, with pain, crepitus, and/or a palpable clunk on examination being suggestive of SL instability.

Significant injury and static SL dissociation are evidenced by a widened SL interval on posteroanterior radiographs (>3 to 5 mm) and increased SL angle on the lateral view (>60° to 70°); an abnormal appearance of the scaphoid (ie, cortical ring sign) and lunate (ie, triangular, trapezoidal, moon-like) may be present as well (Figure 1).[14] Pencil-grip posteroanterior radiographs are useful to exaggerate the findings of dynamic SL instability and identify cases with dynamic (rather than static) SL instability.[32] Contralateral radiographs are helpful to compare the injured side to the patient's normal anatomy, as significant variability exists in the normal population.[19] Magnetic resonance

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TABLE 1
Differential for Middorsal Wrist Pain in Athletes[a]

Origin	Diagnosis	Common Examination Findings, Provocative Maneuvers
Traumatic and overuse injuries	• Gymnast's wrist • SLIL injury/instability • Second and third CMC joint injuries • Second and third CMC carpal boss	• Pain with wrist hyperextension, radial deviation • Scaphoid shift test (Watson maneuver) • Second and third CMC shuck, torque, and Kleinmann compression tests • Firm, immobile prominence; does not transilluminate
Tendinopathy and tendon instability	• EPL tenosynovitis • ECRB insertional tendinitis • Fourth-compartment syndrome • aEIP • EDC tenosynovitis • EDBM	• Pain with resisted thumb extension • Resisted dorsiflexion, passive palmar flexion • Resisted index finger extension with wrist flexion (EIP test) • Resisted finger and wrist extension • Loading wrist in full extension
Dorsal impingement syndromes	• Capsular impingement • Ganglion cyst • Occult dorsal ganglion	• Pain loading wrist in full extension (tabletop push off) • Dorsal soft tissue mass, positive transillumination • TTP over scapholunate interval
Neurologic	• PIN syndrome • SRN compression (Wartenberg syndrome)	• Point tenderness proximal to Lister tubercle, positive relief with selective PIN block • Positive Tinel sign over SRN; positive Finkelstein test (traction on nerve); positive symptoms with wrist flexion, ulnar deviation, and pronation for 1 min
Vascular	Lunate AVN (Kienböck disease)	• TTP of the lunate

[a]aEIP, anomalous extensor indicis proprius; AVN, avascular necrosis; CMC, carpometacarpal; ECRB, extensor carpi radialis brevis; EDBM, extensor digitorum brevis manus; EDC, extensor digitorum communis; EIP, extensor indicis proprius; EPL, extensor pollicis longus; PIN, posterior interosseous nerve; SLIL, scapholunate interosseous ligament; SRN, superficial branch of radial nerve; TTP, tenderness to palpation.

imaging (MRI) should be obtained if radiographic findings are equivocal.[56,62]

Treatment of SLIL injuries is guided by injury acuity and the presence of static or dynamic instability. Discussing time frames and short-term (season), medium-term (career), and long-term (postcareer) goals for the patients is important. Mild SL injuries with occult instability and minimal pain can be treated nonoperatively using immobilization, activity restriction, and serial examinations for the development of dynamic instability.

Primary repair or SL reconstruction is indicated for painful, dynamic instability (eg, pain, clicking, snapping) or occult instability that has failed nonoperative management. Early repair (<6 weeks) has been shown to produce better outcomes. A number of techniques have been described with no consensus on the optimal treatment method for these patients.[69] SL transosseous screw and wire fixation, direct SLIL repair using suture anchors, and repair augmentation using suture tape and/or dorsal capsule tissue have all been described in an effort to optimize repair strength and healing potential.[60] The timing of surgery depends on the functional demands of the athlete; in the absence of static SL dissociation, a football lineman, for example, may be able to play using a dorsal blocking orthosis and delay surgery until the end of the season. For athletes for whom protected play is not an option (eg, basketball point guard or baseball shortstop), early surgery may be appropriate.[2,14] Again, use of the acronym, "APPLES," has helped guide us in determining treatment and return to play. Use of performance-enhancing drugs such as anabolic steroids has been shown to cause long-term ligament damage and can complicate standard orthopaedic procedures.

Postoperatively, our patients' wrists are immobilized in a thumb spica short arm cast for 10 weeks, at which point any temporizing fixation (eg, K-wires) is removed and standard wrist motion protocols are initiated. Strengthening begins 1 month after motion therapy. Timing for return to sports varies depending on the sport and the athlete's functional demands, as those able to play in a protective orthosis can safely return earlier (ie, 3 months).[2] Otherwise, unprotected return to sports begins after grip strength is 85% of that of the uninjured side, usually at 5 months postoperatively.[14]

*Address correspondence to Zachary C. Hanson, MD, Department of Orthopedic Surgery, Wellstar Atlanta Medical Center, 303 Parkway Drive NE, Atlanta, GA 30312, USA (email: Zchg47@gmail.com).
†Department of Orthopedic Surgery, Wellstar Atlanta Medical Center, Atlanta, Georgia, USA.
‡The Hand & Upper Extremity Center of Georgia, Atlanta, Georgia, USA.
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Second and Third Carpometacarpal Injuries

The second and third carpometacarpal (CMC) joints form a central stabilizing pillar of palmar arch about which the thumb, ring, and small fingers move; robust stability is provided by stout ligamentous connections and interlocking articulations with the trapezoid and capitate (quadrangular joint). Minimal joint motion and limited ability to accommodate elastic deformation make these joints susceptible to traumatic capsuloligamentous injury (eg, sprains or rupture) and dorsal avulsion injuries. Wrist-jamming injuries with direct axial compression of the CMC joints (eg, thrown punch) or volar-to-dorsal forces across the CMC joints with the wrist flexed (eg, golfers) are common culprits. These second and third CMC joint sprains and subtle avulsion fractures are recognized as being relatively common causes of unrecognized chronic wrist pain.[26]

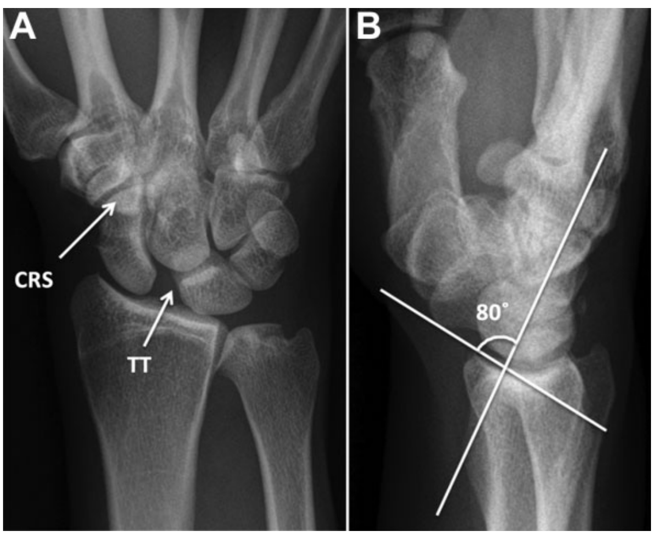

Figure 1. (A) Anteroposterior radiograph showing a widened scapholunate (SL) interval, sometimes referred to as the “Terry Thomas sign” (TT), and malalignment of the scaphoid, with a cortical ring sign (CRS). (B) Lateral radiograph showing dorsal tilt of the lunate. The SL angle is measured from a tangential line along the volar aspect of the distal and proximal pole of the scaphoid and a line through the midaxis of the lunate. Here the SL angle is approximately 80°; angles >70° are indicative of a complete tear of the SL ligament. (Reproduced with permission from Rajan PV, Day CS. Scapholunate interosseous ligament anatomy and biomechanics. *J Hand Surg Am*. 2015;40[8]:1692-1702.)

A carpal boss refers to an often reactive, hypertrophic-appearing bony prominence over the dorsal base of the second and third metacarpals overlying the CMC joints (Figure 2). Carpal boss formation is thought to represent degenerative osteophyte formation (eg, chronic injury with long-standing CMC joint instability), as seen in Figure 2, or an os styloideum (ie, accessory ossification center).[8] Carpal bosses may become symptomatic because of an acute injury (eg, fracture or contusion); associated ganglion cyst formation; or repetitive overuse and inflammation of the overlying bursa, extensor carpi radialis brevis (ECRB), and extensor carpi radialis longus (ECRL) tendons from sliding over the bony prominence.[8] Symptomatic carpal bosses most commonly develop in the dominant hand of athletes performing repetitive loading of the wrist in extension, such as gymnastics, golf, and racquet sports.[41]

Clinically, patients have pain localized dorsally over the second and third CMC joint complex that is exacerbated by forced wrist extension.[41] A carpal boss may be present as a bony, immobile prominence and is most noticeable with the wrist flexed, although it can be masked by overlying soft tissue swelling (eg, bursitis, associated ganglion).[34] Painful laxity and/or palpable crepitus may be elicited via provocative maneuvers to stress the CMC joints, such as the CMC shuck test, torque test, and Kleinmann compression test (Figure 3).[17] Diagnostic lidocaine injections of the second and third CMC joint complex are useful to confirm the source of pain.

Radiographs for suspected second and third CMC joint injuries and/or carpal bossing should include a “carpal boss view,” with the hand in 30° of supination and ulnar deviation (Figure 2).[9,17] While radiographs are typically sufficient for a diagnosis, advanced imaging using computed tomography (CT) or MRI may be indicated in more complicated cases (Figure 4).[42,68]

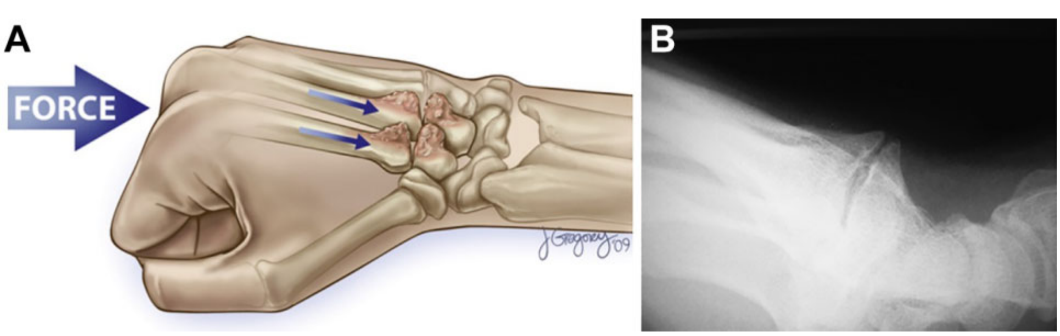

Figure 2. (A) Repetitive, traumatic axial loads from the metacarpophalangeal joints across the carpometacarpal joints are thought to be a cause of traumatic carpal boss formation. (B) Radiograph demonstrating traumatic carpal boss formation characterized by hypertrophic spur formation dorsally and articular degenerative changes. (Reproduced with permission from Melone CP Jr, Polatsch DB, Beldner S. Disabling hand injuries in boxing: boxer’s knuckle and traumatic carpal boss. *Clin Sports Med*. 2009;28[4]:609-621.)

Figure 3. Clinical photographs depicting provocative examination maneuvers for second and third carpometacarpal joint injuries. (A) The shuck test is performed by applying dorsal pressure to the second and third metacarpal heads with the wrist stabilized. (B) The torque test is performed using forceful pronation-supination of the index and middle fingers with the wrist stabilized. (C) The Kleinmann compression test is performed by compressing across the second and fifth carpometacarpal joints with the wrist stabilized. Positive provocative testing is evidenced by reproduction of pain and/or appreciable crepitus or laxity compared with the contralateral hand.

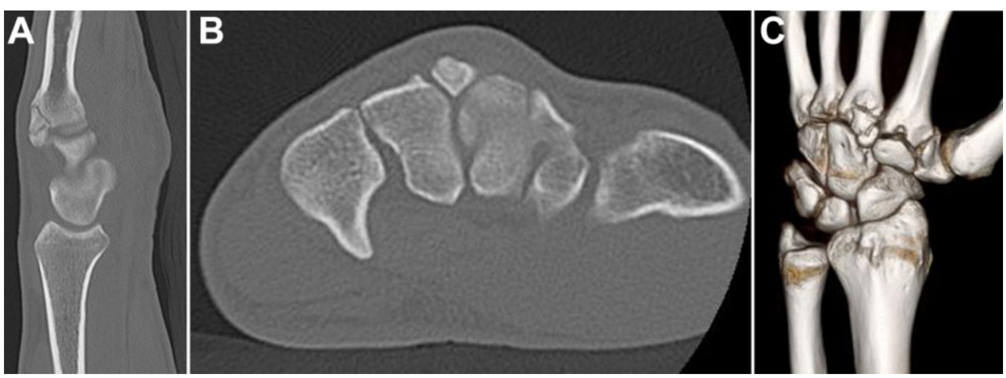

Figure 4. (A) Sagittal, (B) axial, and (C) 3-dimensionally reconstructed computed tomography images of a patient with a symptomatic carpal bossing of the second and third carpometacarpal joint complex.

Initial nonoperative management with nonsteroidal anti-inflammatory drugs (NSAIDs), corticosteroid injections, splint immobilization, and hand therapy is typically recommended for symptomatic carpal boss lesions. Acute injuries such as fracture of a preexisting carpal boss in high-level athletes can often be treated nonoperatively in-season, using splint immobilization and lidocaine injections to facilitate return to play and customized CMC boss splints that fit inside sport-specific gloves during competition. Patients with persistent symptoms affecting performance may require operative treatment in the off-season, which involves surgical excision of the nonunited fragment, taking care to preserve the ECRB and ECRL tendinous insertions.

Chronic pain and limited function that have not benefitted from nonoperative treatment are not uncommon, particularly in high-level athletes, and may ultimately require surgical treatment involving carpal boss excision and/or primary fusion.[41] Wide-wedge carpal boss excision is favored by many as the treatment of choice and is performed via a transverse dorsal incision overlying the base of second and third metacarpals, taking care to avoid the tendinous insertions of the ECRB and ECRL; the carpal boss and adjacent sclerotic bone are excised in their entirety, leaving a small concavity of bone adjacent to the normal articular surface.[17,41] The primary concern with this procedure is disruption of the dorsal CMC joint ligaments, leading to destabilization and symptom recurrence that ultimately requires CMC joint fusion.[5]

Distal Radial Physeal Stress Syndrome (Gymnast's Wrist)

Distal radial physeal stress injuries, commonly referred to as "gymnast's wrist," are most commonly seen (approximately 90%) in female patients aged 12 to 14 years who practice >35 hours per week.[44] Repetitive microtrauma to the physis and surrounding vasculature leads to abnormal mineralization of the physis and pathologic widening.[24,50] The condition is considered to have 3 general stages: preradiographic (stage 1), radiographic changes present (stage 2), and radiographic changes with ulnar positive variance (stage 3).

In stage 1, the diagnosis is made clinically. Patients are evaluated with unilateral or bilateral wrist pain that begins during training, is worse during events that load the wrists, and resolves with rest. Tenderness is typically localized to the dorsal radius and carpus, with motion being normal or mildly limited from pain. In patients with more advanced

Figure 5. (A) Posteroanterior (PA) radiograph showing the radiographic appearance of normal epiphyseal, physeal, and metaphyseal relationships. (B) PA radiograph obtained in a 10-year-old elite gymnast demonstrating typical traumatic osteolysis of the distal radius with widening of the growth plate (curved white arrow), irregularity of the metaphyseal side of the physis (straight white arrows), and reactive metaphyseal sclerosis (black arrow). (C) Sagittal T1-weighted magnetic resonance imaging scan revealed growth plate widening, particularly dorsally (curved white arrow). The metaphyseal physis irregularity (black arrows) is because of the widening of the hypertrophic zone of the growth plate and can develop cystic-appearing changes with continued trauma. (Reproduced with permission from Blankenbaker DG. *Diagnostic Imaging: Musculoskeletal Non-Traumatic Disease E-Book.* Elsevier Health Sciences; 2016.)

disease (stages 2 and 3), radiographic changes are present, which include widening of the distal radial physis with ill-defined borders (Figure 5). Ulnar positivity in these patients is almost always abnormal (adolescents with open physes generally have ulnar negative variance) and indicates more severe, long-standing disease.[12] MRI scans are not routinely obtained but will show bony contusion of the distal radius, paraphyseal edema, and/or physeal bar formation.

Initial treatment recommendations focus on rest from the inciting activity. Activities involving loading or compression of the wrist should be avoided for a minimum of 6 weeks, although patients may continue alternative, supervised conditioning programs.[12] Complete resolution of radiographic changes is not required to begin return to sports, as changes often lag behind clinical progression. Patients who are pain-free, have a normal examination, and show continued improvement of radiographic changes may begin sport-specific training with a focus on biomechanics and form; patient education aimed at injury prevention is a key aspect for the long-term health of these patients. Operative intervention is only indicated for cases of severe disease with significant growth disturbance and involves physeal bar excision and/or joint-leveling procedures.

Avascular Necrosis of the Lunate (Kienböck Disease)

Kienböck disease refers to avascular necrosis of the lunate and is the most common type of idiopathic carpal avascular necrosis.[35] Its origin remains unclear and is likely multifactorial, with local vascular and osseous abnormalities being most commonly implicated. It is most common in men aged 20 to 40 years. Presenting symptoms are often similar to those of wrist sprain without a history of trauma. Dorsal wrist tenderness over the lunate with adjacent reactive synovitis and soft tissue swelling is common. Decreased grip strength and pain with motion are usually present and exacerbated by activity, particularly with extension and axial loading across the wrist (eg, push-ups or military press).[35] Early recognition is challenging, as plain radiographs appear normal; patients with otherwise unexplained middorsal wrist pain, particularly younger patients, should be evaluated using an MRI scan. A diagnosis is confirmed by the presence of uniform signal change of the lunate compared with the rest of the carpus (Figure 6).

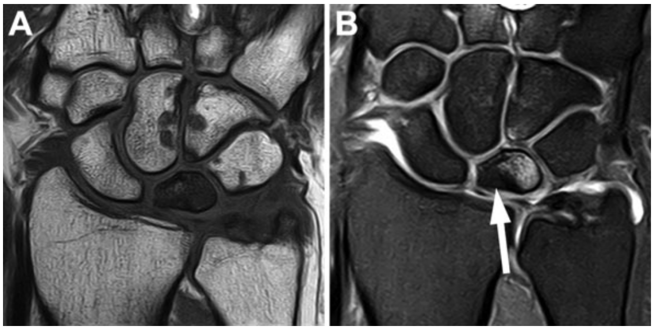

Figure 6. A 34-year-old patient diagnosed with stage 2 Kienböck disease. (A) A coronal T1-weighted magnetic resonance imaging (MRI) scan shows uniform, low signal intensity within the lunate. (B) A coronal fat-suppressed T2-weighted MRI scan shows low signal intensity over the radial aspect of the lunate, indicating partial necrosis (arrow). (Reproduced with permission from Llopis E, Restrepo R, Kassarjian A, Cerezal L. Overuse injuries of the wrist. *Radiol Clin North Am*. 2019;57[5]:957-976.)

Treatment is guided by patient symptoms and radiographic staging of disease. Symptomatic patients in early stages of disease are typically treated initially with cast

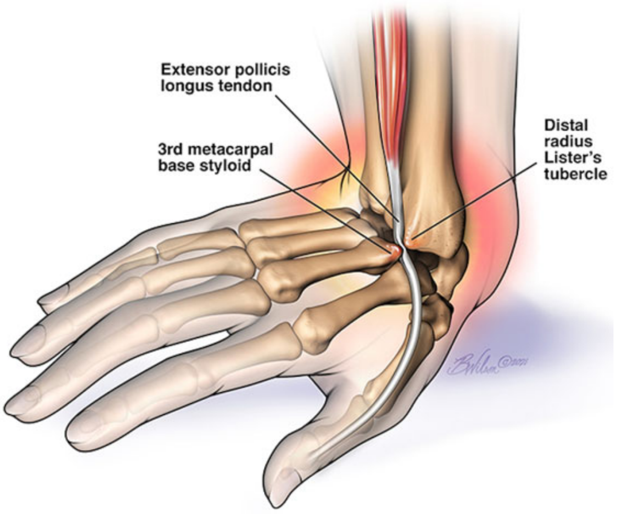

Figure 7. Illustration depicting the pathomechanics of extensor pollicis longus (EPL) tenosynovitis: traumatic wrist hyperextension causes impingement of the EPL tendon between the base of the third metacarpal and the Lister tubercle of the distal radius, leading to tendon inflammation and swelling.

immobilization. Continued disease progression may require surgery; goals of early treatment are to slow or stop progression by improving lunate vascularity (eg, direct vascularization or vascularized bone grafting) and/or via joint-leveling procedures (eg, radius-shortening or ulna-lengthening osteotomies). Treatment in later stages is palliative and performed in an attempt to limit continued carpal collapse (eg, proximal row carpectomy, wrist arthrodesis, denervation).

TENDINOPATHY AND TENDON INSTABILITY

Extensor Pollicis Longus Tenosynovitis

Classically described as a drummer's palsy,[11] stenosing tenosynovitis of the extensor pollicis longus (EPL) is seen in patients subject to long-term, repetitive wrist hyperextension (eg, gymnasts, platform divers). The pathomechanics are thought to involve impingement of the EPL tendon between the base of the third metacarpal and the Lister tubercle, leading to inflammation, swelling, and a subsequent discrepancy in size between the EPL and its tight, inelastic fibrous compartment (Figure 7).[16] Limited tendon gliding through the third compartment results in a painful snapping sensation and can progress to attenuation and rupture of the tendon.[1,28]

A similar clinical condition may be seen in athletes after a traumatic hyperextension injury of the wrist. Approximately 5% of patients with a minimally or nondisplaced distal radius fracture (or similar high-energy injury to this area) are evaluated with signs of impending or complete EPL tendon rupture.[49] Traumatic injuries in this area can disrupt the tendon's blood supply or cause compressive swelling (eg, hematoma formation) within the third extensor compartment, which decreases perfusion and leads to ischemic injury.[15,23,28]

Patients are evaluated with pain and swelling around the Lister tubercle that is exacerbated with passive stretch and active firing of the EPL. Palpable clicking or snapping may be felt with EPL firing in cases of stenosing tenosynovitis. Radiographs can be useful in identifying any bony prominence as a source of attritional tendon injury or a fracture in the setting of a recent trauma. MRI scans will reveal tendon enlargement along with midsubstance and paratenon edema and associated synovitis.[28] Ultrasonography has been shown to be a useful imaging modality for these cases and is a sensitive means of detecting tendinosis and tenosynovitis.[21,63]

Surgical treatment is generally recommended for these patients because of the high risk for tendon rupture and involves release of the third extensor compartment with possible allograft reconstruction or tendon transfer, depending on the degree of attritional injury to the tendon.[28] While corticosteroid injections may provide a period of pain relief, these are typically avoided in athletes, as they can lead to tendon attenuation and increased risk for rupture. Patients evaluated with acute pain after a traumatic injury (eg, with a nondisplaced distal radius fracture) may be treated with attempted needle aspiration to decompress the third extensor compartment. In these cases, the patient should be followed closely for resolution of symptoms, and the surgeon should have a low threshold to decompress this compartment surgically to avoid tendon rupture.

ECRB Insertional Tendinitis

Insertional tendinitis of the ECRB can be a disabling cause of pain, particularly in high-level athletes.[26] Repetitive, forceful contraction of the ECRB seen with gymnastics, weight lifting, and racquet or stick sports (eg, baseball, tennis, golf) can cause microtrauma to the tendinous insertion of the ECRB. Long-standing tenosynovitis eventually leads to interstitial tendinosis and tendon attenuation.

Patients are typically evaluated with activity-related pain over the base of the second and third metacarpals. In golf, baseball, and lacrosse athletes, the pain is typically in the dominant hand and reproduced at the top of the backswing maximal dorsiflexion; pain can also occur at the point of impact with the ball (eg, golf, baseball).[36] On physical examination, there may be point tenderness, swelling, and bogginess over the base of the third metacarpal. Pain with resisted dorsiflexion and passive palmar flexion of the wrist is suggestive of ECRB insertional tendinitis.[27] Plain-film radiographs are unremarkable, with an isolated insertional tendinitis; however, an associated second and third CMC boss may be present and should raise concern for pending tendon rupture. MRI scans will show edematous changes to the distal ECRB and its insertion.

Early treatment of ECRB insertional tendinitis is nonoperative, primarily via rest/activity avoidance and use of NSAIDs. Corticosteroid injections can be helpful to reduce inflammation and improve pain but should be used with caution, as they may lead to tendon attenuation and risk

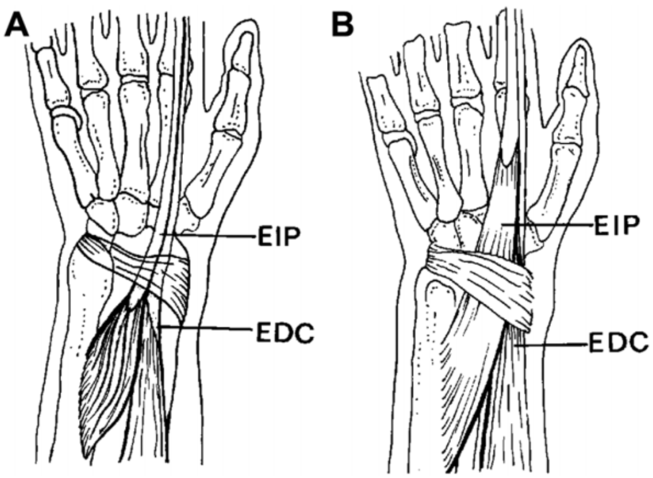

Figure 8. (A) Normal anatomy of the fourth extensor compartment of the wrist. The extensor indicis proprius (EIP) becomes tendinous just before entering the extensor compartment and has a 1:1 muscle to tendon ratio. (B) An anomalous EIP with the muscle belly extending through the fourth compartment into the dorsum of the hand, resulting in increased volume and pressure within the relatively rigid compartment sheath, causing inflammation, pain, and disability. EDC, extensor digitorum communis. (Reproduced with permission from Tan ST, Smith PJ. Reversed extensor indicis proprius muscle and dorsal wrist pain: case report. *Br J Plast Surg.* 1998;51[2]: 128-130.)

for rupture in patients who continue activity. Goals for nonoperative treatment are complete symptom relief and full range of motion by 6 weeks, followed by 2 weeks of gradual strengthening and initiation of sport-specific training around week 12, after the patient's wrist has reached 85% of the strength of the contralateral side. Patients with mild symptoms or faster progression through this general protocol may return to sports sooner.

Surgical treatment with tenosynovectomy is indicated after 6 to 12 months of failed nonoperative treatment. Insertional rupture is less common but can occur because of an acute-on-chronic injury, particularly in patients with a history of local corticosteroid injections; surgical repair using suture anchors or temporizing interosseous wire fixation should be performed within 7 to 10 days to avoid tendon shortening. Postoperatively, patients have their wrists immobilized for 2 weeks, followed by range of motion therapy; at 6 weeks postoperatively, the rehabilitation protocol is the same as the nonoperative treatment described earlier.

Fourth-Compartment Syndrome: Anomalous Muscles and Tenosynovitis

The extensor indicis proprius (EIP) muscle originates along the distal third of the ulna and passes within the fourth compartment, deep and ulnar to the extensor digitorum communis (EDC) tendons; the EIP muscle to tendon ratio is approximately 1:1, with the musculotendinous junction located within the confines of the fourth dorsal extensor compartment,[4] normally leaving just enough space for the EIP and EDC tendons to glide freely within the compartment as the fingers are maximally flexed. Anomalous hand and wrist muscles that increase the space occupied within the fourth compartment can cause pathologic increase in compartment pressure with subsequent tenosynovitis, irritation of the posterior interosseous nerve (PIN), pain, and disability.

An anomalous EIP (aEIP) has been identified in approximately 4% of the population,[4,33,39,52] with the musculotendinous junction located distal to the confines of the dorsal compartment. In these patients, the aEIP muscle belly fills most of the compartment at rest (as opposed to during full finger flexion) and passes through it entirely during wrist flexion, exceeding the limited space available; constriction by the extensor retinaculum in these patients leads to synovitis and/or ischemia of the aEIP muscle, causing pain and disability (Figure 8).[6,7,46,57] EIP syndrome refers to tenosynovial proliferation, which develops around the bulky musculotendinous junction in patients with an aEIP.[46]

The extensor digitorum brevis manus (EDBM) is an aberrant dorsal hand muscle seen in an estimated 2% to 3% of the population, with >50% of cases occurring bilaterally.[67] Most commonly, the EDBM originates over the distal radius periosteum, dorsal carpal ligaments, or wrist capsule overlying the proximal carpal row and inserts on the ulnar aspect of the metacarpophalangeal joint extensor hood of the index finger.[18,40] Its innervation and blood supply are from the PIN and posterior interosseous artery, respectively. Most patients with an EDBM are asymptomatic, with symptomatic cases being much more likely among athletes or highly active patients (eg, heavy laborers); muscle hypertrophy in these patients leads to painful synovitis from compression or impingement against the distal edge of the extensor retinaculum.[13,31,45] Symptomatic EDBM syndrome can often be mistaken for a ganglion cyst, which presents similarly, and it has been reported to occur with a coexisting ganglion cyst in several cases, which may contribute to development of symptoms.[40]

EDC tenosynovitis is a related clinical disorder that is characterized by long-standing inflammation and pathologic thickening of the EDC tenosynovium, which creates a cycle of increasing constriction within the fourth extensor compartment (Figure 9).

As with most uncommon clinical pathologies, the most important factor for diagnosing symptomatic anomalous muscles requires knowledge that this condition exists and maintaining a degree of clinical suspicion. Patients often have a fusiform soft tissue mass distal to the extensor retinaculum, similar in appearance to a ganglion cyst or soft tissue tumor (eg, lipoma), that is mobile, does not transilluminate, and becomes firm with wrist flexion and finger extension.[40,59] Dorsal wrist pain is exacerbated by activity with the wrist in flexion, and tenderness is localized along the aEIP and EDC tendons in the fourth compartment.[46] The EIP test is a provocative maneuver for detecting an aEIP and involves resisted index finger extension with the wrist in flexion (to maximally fill the fourth dorsal

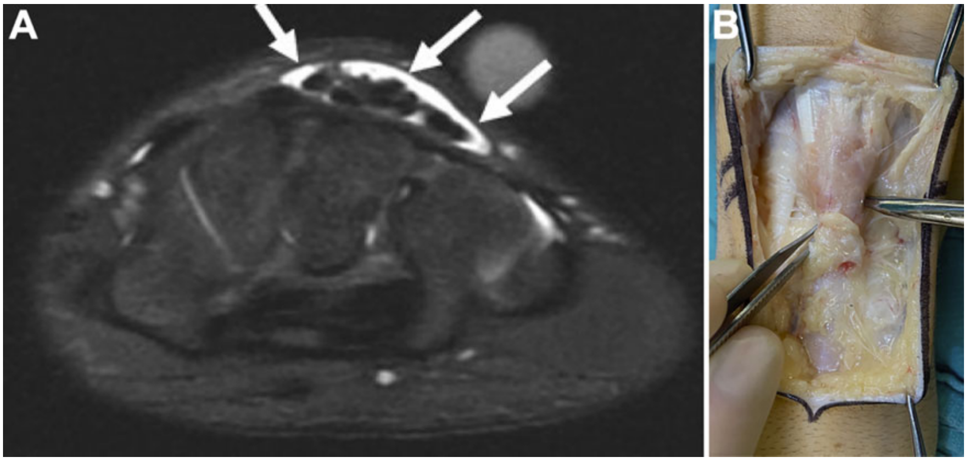

Figure 9. (A) Fat-suppressed T2-weighted magnetic resonance imaging scan obtained in a 17-year-old gymnast with inflammation within the fourth extensor compartment (arrows) indicative of tenosynovitis caused by overuse and dorsal impingement by an underlying carpal boss found on other imaging studies. (B) Intraoperative photograph obtained in a patient with extensor digitorum communis tenosynovitis; note the thickened tenosynovium adjacent to the distal border of the extensor retinaculum (shown between the surgical instruments) causing dorsal wrist impingement, pain, and disability in this patient. (Image A reproduced with permission by Fritz RC, Boutin RD. Musculotendinous disorders in the upper extremity, part 2: MRI of the elbow, forearm, wrist, and hand. *Semin Musculoskelet Radiol*. 2017;21[4]:376-391.)

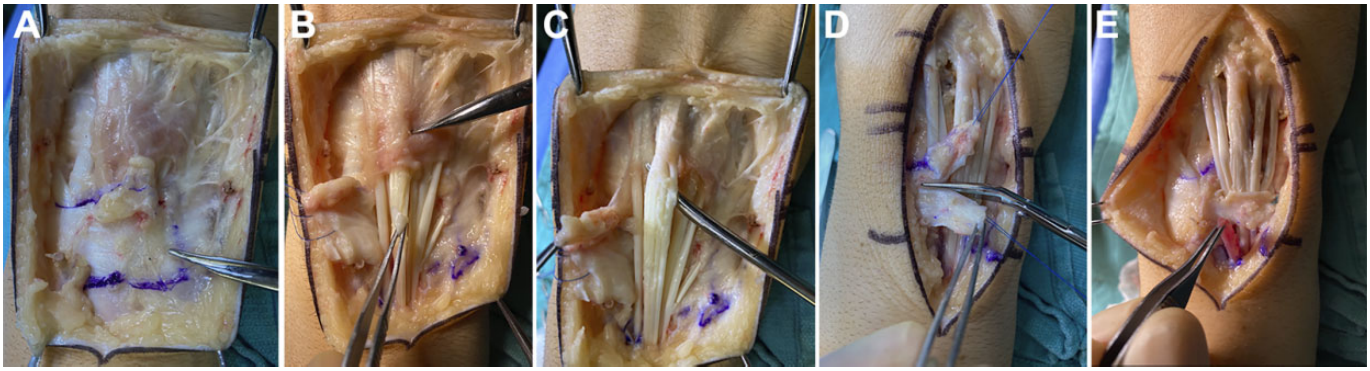

Figure 10. Intraoperative photographs of surgical excision of symptomatic, thickened extensor digitorum communis tenosynovium. (A) Exposure visualizing the pathologic tenosynovitis and adjacent extensor retinaculum, outlined with marking pen. The extensor retinaculum is incised and reflected (B) to decompress the fourth compartment, followed by (C) tenosynovectomy and tenolysis. (D) The distal half of the extensor retinaculum is excised to decrease risk for recurrent impingement, and (E) the proximal half of the extensor retinaculum is repaired to prevent tendon bowstringing during wrist extension.

compartment).[57] Similar provocative maneuvers are performed for EDBM and EDC tenosynovitis with resisted finger and wrist extension in flexion. Extensor tendon triggering in these patients is uncommon[25] but has been observed to involve digits with dual extensor tendons or anomalous extensor tendons secondary to impingement on the dorsal extensor retinaculum; the presence of additional tendon(s) in the limited space of each fibro-osseous compartment leads to the development of tenosynovitis, further tendon constriction, and subsequent triggering on the extensor retinaculum.[29]

Radiographs are negative, but use of MRI scans can be helpful to confirm the presence of anomalous hand and wrist muscles passing through the fourth compartment. Patients should be evaluated for coexisting ganglion cysts as a contributing source of pain, which have been reported in as many as 25% of these patients.[13,40]

Initial treatment is typically nonoperative, with rest, NSAIDs, activity modification, splinting, and corticosteroid injections.[46] Patients who do not respond to prolonged nonoperative treatment should raise suspicion for the presence of aberrant anatomy (eg, anomalous muscle or tendon). Surgery is indicated for patients without improvement despite 3 to 6 months of nonoperative treatment, which involves decompression via surgical release of the fourth extensor compartment; concomitant tenosynovectomy and reduction or excision of associated anomalous muscles may be performed to decrease the risk of recurrence, particularly in patients who plan to return to sports (Figure 10).[6,7,31,46,48]

DORSAL IMPINGEMENT SYNDROMES

Dorsal Capsular Impingement

Primary dorsal wrist impingement (DWI) refers to a disorder characterized by middorsal wrist pain attributed to capsulitis or synovitis of redundant capsular tissue impinging between the ECRB tendon and dorsal ridge of the scaphoid. The inciting injury may be relatively minor but leads to swelling and thickening of capsular tissue that is prone to recurrent episodes of impingement and a cycle of aggravation with persistent inflammation. In chronic cases, osteophytes may develop along the dorsal scaphoid, lunate, or dorsal rim of the distal radius, which leads to worsening impingement and dorsal impaction.[44]

Pain is localized to the ECRB, where it passes over the dorsal scaphoid, which is exacerbated with full wrist extension and loading of the wrist in an extended position (eg, tabletop push-off test).[38] The diagnosis is made clinically after secondary causes (eg, impingement due to occult ganglion or SL instability) have been ruled out.[22] Plain-film radiographs are typically normal, and CT scans may show the development of small osteophytes. MRI scans can be helpful in confirming DWI, which may show dorsal capsular thickening and redundancy with signs of inflammation in this area (Figure 11).

Figure 11. Sagittal STIR (short-tau inversion recovery) magnetic resonance imaging used to suppress fat tissue and enhance signal from any inflammatory tissues in a patient with suspected dorsal capsular impingement. Dorsal capsulitis is evidenced by increased signal intensity over the dorsal capsule and adjacent synovium (arrow).

Most cases of DWI will resolve with 2 to 3 months of rest, splint immobilization, and NSAIDs. Corticosteroid injections are helpful to break the cycle of capsular inflammation and swelling and often provide significant (70%) pain relief for several weeks.[22] Surgical treatment may be indicated for refractory cases that fail nonoperative management. Recent literature has supported arthroscopic synovectomy and capsulectomy with debridement of osteophytes in combination with excision of the distal PIN.[22,38] Open capsulectomy and excision of the dorsal ridges of the scaphoid and lunate have been described as well.[64] Postoperatively, patients are placed in a removable wrist orthosis and begin immediate range of motion therapy, with the goal of full wrist motion at 2 to 3 weeks. Strengthening begins after full motion is achieved, and athletes may begin a return-to-sports protocol around 6 weeks postoperatively, when strength is 80% that of the contralateral side. Athletes should be counseled that return to high levels of activity may lead to the recurrence of symptoms. Surgical intervention has been shown to be a safe and effective method of pain relief and return to sports for patients who have undergone the appropriate diagnostic work-up and who meet the indications for surgery.[38]

Occult Dorsal Carpal Ganglion

Occult dorsal ganglion cysts may result from athletic activity and lead to a dorsal impingement syndrome. The majority (60%-70%) of these mucin-filled cysts originate from the SL ligament and most commonly present as a cystic mass extruding between the EPL and EDC tendons. Smaller, occult dorsal wrist ganglions are more difficult to identify. An inciting injury to the SL ligament and subsequent degenerative change is thought to lead to formation of occult ganglion cysts, although an inciting injury is only reported in about 10% of patients.

Diagnosis should be considered for all athletes with dorsal wrist pain that becomes worse with dorsiflexion and loading across the wrist joint. Patients will have maximal tenderness over the SL interval,[58] which is identified on examination by palpating the soft tissues directly over the wrist in line with the Lister tubercle, which may be exacerbated by passive hyperextension of the wrist. Plain radiographs appear normal, although use of ultrasonography or MRI can be helpful to make a diagnosis, each with similar sensitivity and specificity.[20]

Initial treatment is nonoperative, with corticosteroid injection directly into the wrist capsule followed by a period of splint immobilization, which can provide pain relief and help with diagnosis. Surgical intervention is effective for patients with significant activity-limiting pain and nonoperative treatment that has failed. Open or arthroscopic excision of the dorsal capsule at its attachment to the SL ligament and debridement of the dorsal ligament with decompression of the cyst within its midsubstance, with care taken to avoid destabilization of the SL joint,[61] are often performed in combination with excision of the distal PIN to more reliably alleviate pain.[44]

Distal PIN Syndrome

The PIN is the terminal branch of the radial nerve, which passes through the 2 heads of the supinator and travels to the wrist along the radial floor of the fourth extensor compartment, just ulnar to the Lister tubercle. Terminal sensory branches of the PIN cross dorsally over the SL ligament and innervate the dorsal capsule of the wrist.[10]

Athletes whose sports require repetitive, forceful hyperextension of the wrist (eg, gymnasts, football linemen and defensive backs, platform divers, weight lifters), particularly those with hypermobility at baseline, may experience dorsal wrist pain secondary to impingement of the PIN at the wrist as described by Carr and Davis.[3] On examination, these patients will have pain exacerbated by maximal dorsiflexion of the wrist as well as tenderness localized to the fourth extensor compartment along the course of the PIN.

Initial treatment for athletes with suspected distal PIN impingement is nonoperative; in a small case series, >50% of athletes improved with a period of immobilization and NSAIDs.[3] Incomplete pain resolution and inability to return to sports often indicate significant perineural scarring and hypertrophy, and surgical treatment is indicated[3]; PIN neurectomy has been shown to be a safe and effective procedure for providing pain relief in most patients.[3,66]

CONCLUSION

Hand and wrist injuries are common in athletics and can have a significant effect on a patient's ability to perform. Middorsal wrist pain is a relatively common concern, yet there is relatively little literature discussing these pathologies compared with more common causes of radial and ulna-sided wrist pain. Knowledge of this differential and special considerations for these diagnoses in athletes are important to effectively treat these players and achieve their goals related to sports.

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