Chapter 12

The Aging Wrist: An Orthopedic Perspective

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ANATOMY AND BIOMECHANICS OF THE WRIST

The wrist is the most complex and least understood joint in the human body. It is the final adjusting unit of prehension in the upper extremity. It acts as a mechanical transducer and shock absorber for both extrinsic stress to the hand on one side and the action of the fingers on the other. Its boundaries are somewhat nebulous. Distally, the region of the wrist consists of an area bounded by the five metacarpals, eight carpal bones, and proximally by the distal end of the radius and the ulna. There is a bewildering array of articulations whose movements are governed by interlocking three-dimensional geometric constraints as well as a myriad of intrinsic and extrinsic powerful restraining ligaments.[9] Curiously, the wrist has no intrinsic musculature; rather, its complex movement is governed by muscle tendon units that cross it at its periphery.

For purposes of this discussion, the wrist will "begin" at the junction of the diaphysis and the metaphysis of the distal radius and ulna.

In the adult, this represents a rather abrupt transition from bone that is primarily tubular and cortical to cancellous bone with a thin cortical shell (the significance of this will be apparent later). The dorsal aspect of the radius has prominences that form tunnels for the extrinsic tendons, as well as attachments for the extensor retinacular. The radius fans into a triangular structure bearing essentially three articular surfaces: the scaphoid fossa, which tapers radially by the radial styloid; the lunate fossa; and the sigmoid notch for the articulation with the distal ulna. The ulna caput has nearly a circular cross section with articular cartilage covering a 300-degree arc, which allows for the extensor carpi ulnaris groove and the ulnar styloid. The distal end of the ulna is covered by articular cartilage, except for the styloid, which forms an attachment site for the numerous intercarpal ligaments and the triangular fibrocartilage. The articular disc of the triangular fibrocartilage stretches over the distal ulna and inserts on the ulnar side of the lunate fossa of the distal radius. This complex also has a myriad of vertical ligaments that connect the articular disc with the distal ulna and the ulnar carpus.

Distally, the proximal carpal row consists of the scaphoid, lunate, triquetrum, and pisiform. The scaphoid is considered to be a functional bridge between the proximal and distal carpal rows, comprising the trapezium, trapezoid, capitate, and hamate. These, in turn, articulate with the metaphyseal bases of the metacarpals (Fig 12–1). Curiously, the trapezium joins with the bases of the thumb and index metacarpals; the trapezoid with the ulnar half of the second metacarpal; the hamate with the fourth and fifth metacarpal; and the capitate with an exclusive third metacarpal articulation. In cross section, the carpus forms the shape of a Roman arch with the lunate capitate axis as the keystone. The long axis of the hand begins at the distal radius and continues through the third metacarpal, providing the wrist and hand with longitudinal stability and the mobil-

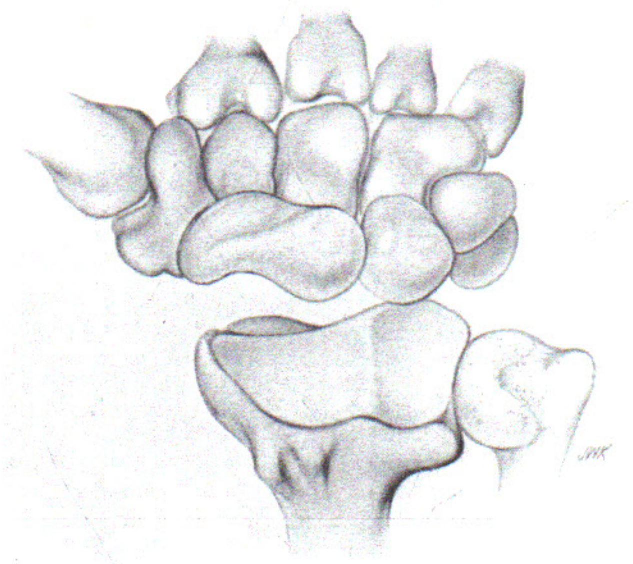

FIG 12–1.
An exploded view of the radiocarpal articulation illustrating the scaphoid and lunate fossa on the distal radius, the distal radioulnar joint articulation, the proximal carpal row with the scaphoid on the left, midcarpal row, and the carpal-metacarpal joints.

ity required for prehension. The scaphoid spans both rows anatomically and functionally and the pisiform is a sesamoid bone that enhances the mechanical advantage of the wrist's most powerful motor, the flexor carpi ulnaris, and also its own joint with the triquetrum. The two main moving articulations in the wrist are the radiocarpal and the midcarpal joints.

Ligaments

The wrist is interlaced with a complex array of intrinsic and extrinsic interosseous ligaments that are capable of inducing bony displacements and transmitting energy at a distance.[14] The palmar ligaments are far thicker and stronger than the dorsal ones. The extrinsic ligaments run from the radius to the carpals and from the carpals to the metacarpals. The interosseous ligaments insert between the carpal bones. The palmar extrinsic ligament system consists of the radial collateral ligament, the palmar radiocarpal ligaments, and the ulnar carpal ligaments. These are divided up into the superficial and deep layers. Superficial layers are V-shaped and provide support during radial and ulnar deviation. Deep ligaments include the radioscaphoid capitate, radiolunate, radioscapholunate, the ulnocarpal complex (including the triangular fibrocartilage complex), the ulnar lunate ligament, and the ulnar collateral ligament. The dorsal extrinsic system is thinner and weaker than the palmar ligaments and connect the radius to the proximal carpal row. The intrinsic ligaments are short, strong fibers that, under most circumstances, connect the carpal bones into a fixed unit and dictate the stereotyped interosseous movement associated with wrist flexion, extension, and radial and ulnar deviation.

Muscles and Tendons

Ten forearm muscles control flexion, extension, pronation, and supination. Six are direct flexors or extensors whose tendons cross the joint over the wrist. The extensor carpi radialis longus and brevis, the extensor carpi ulnaris, the flexor carpi ulnaris, and the flexor carpi radialis insert at the metacarpal bases. Pronation is governed by the pronator teres and the pronator quadratus, and supination by the supinator and the biceps muscles. Six extrinsic tendon compartments cross over the dorsum of the wrist and these tendons effect all finger, wrist, and thumb extension. On the volar side, all the digital flexors cross the wrist in the carpal tunnel and the two wrist flexors cross in their own compartments.

Kinematics

The epicenter of movement instability of the wrist resides at the proximal pole of the capitate. The longitudinal column of the wrist, as previously indicated, consists of the third ray, the capitate, the lunate, and the radius axis. The radial and ulnar columns come off this central axis and provide the mobility required for hand function. Normal wrist flexion is approximately 85 degrees, extension is 75 degrees, with 55% of flexion occurring at the midcarpal joint and 45% at the radiocarpal joint. Total radial deviation is 15 degrees and ulnar deviation is approximately 35 degrees. In radial deviation, the proximal carpal row moves ulnarly and the distal carpal row moves radially. The scaphoid flexes and turns the lunate to a flexed position.[5] The triquetrum moves dorsal to the hamate and disengages it. In ulnar deviation, the scaphoid extends, the lunate extends, and the triquetrum rides up dorsally on the hamate.

There have been several studies to define the range of motion necessary for the activities of daily living. Voltz[16] in 1980 found that as long as the wrist achieves 15 degrees of extension, there is a minimal disturbance of the activities of daily living. Any disruption of the wrist ligaments, e.g., the scapholunate ligament, can cause a serious disability because of the development of instability patterns. These instability patterns occur in two broad categories in a predictable fashion: one is called a dorsal intercalated segment instability, the other is called a volar intercalated segment instability. There is also a predictable pattern of degeneration of the wrist that occurs as a result of the disruption between the scaphoid and the lunate.[8] This is called scapholunate advanced collapse, and results in a painful loss of motion of the wrist.

Wrist-Hand Synergy

Wrist position is critical in augmenting the fine motor control of the hand. Wrist extension allows digital flexors to obtain maximal functional length. Conversely, wrist flexors place the finger in extension. However, digital flexors have little effect on wrist flexion because of their close proximity to the center of rotation of the wrist in the carpal canal. Wrist flexors and extensors cross at the periphery of the wrist and are at an increased mechanical advantage. Voltz[15] in 1975 found that grip strength is maximized at 20 degrees of wrist extension at neutral rotation. Ulnar deviation of approximately 10 to 15 degrees would also maximize grip strength.

THE AGING WRIST

Fundamentally, there are two changes that occur in the wrist with aging: osteopenia and articular degeneration. The latter can occur as a result of wrist trauma earlier in life owing to primary degenerative arthrosis or as a result of an inflammatory process such as rheumatoid arthritis or mineral deposition disease. The former is important because it renders the wrist area extremely vulnerable to a host of classic injury patterns that, unless treated appropriately, can cause severe disability with marked inability to perform even the simple tasks of daily living without constant pain. The other category of dysfunction around the wrist relates to a sequela of neurologic events causing contractures about the wrist, rendering prehension impossible.

Osteoarthritis

The trapezial metacarpal joint is the pivotal interface between the wrist and the thumb, without whose function thumb opposition and apprehension would be impossible. This is a complex saddle joint that allows thumb flexion/extension, abduction, adduction, and circumduction for opposition. There is a complex interplay between the mobility and the stability necessary for power grip. The main static restraint of this joint is the volar oblique ligament, which prevents adduction and proximal migration of the metacarpal owing to deforming forces of the extrinsic and intrinsic musculature about the thumb. The geometry of the carpometacarpal joint with the restraining ligaments forms stable anchors through which extrinsic and intrinsic muscles of the thumb can operate. It is the balance of the muscle forces that ultimately gives the joint its stability. The compressive forces across the carpometacarpal joints are ten times the force generated at the fingertips and proper functioning depends on maintenance of a smooth, congruent joint surface.[3] Anything that renders the joint unstable or incongruent will hasten articular cartilage degeneration. This can occur as a result of major trauma or chronic overuse.

Osteoarthritis in the carpometacarpal joint is common in middle-aged women, predominantly those in their 50s and 60s. Clinically, this condition has been accompanied by joint subluxation. Whether this is a cause or an effect of the degenerative arthritis is unknown. Subluxation is usually radial at the metacarpal base, with formation of large bone spurs in the ulnar side of the trapezium that limit movement (Fig 12–2). The metacarpophalangeal joint may be hyperextended. Onset of pain may be vague and can take months or even years to become clinically evident. Osteoarthritis presents with pain and crepitus, and the characteristic deformity of the radial aspect at the base of the metacarpal at the carpometacarpal joint is visible. Any compressive or rotatory movement becomes very painful. Curiously, there is a poor correlation between the radiologic appearance of the joint and the degree of symptomatology. Patients gradually become unable to perform even the most simple tasks of daily living.

Conservative Management

The initial treatment of CMC arthrosis consists of splinting, rest, heat, ice, and use of anti-inflammatory medications. Joint protection splints that keep the thumb in 45 degrees of abduction but allow

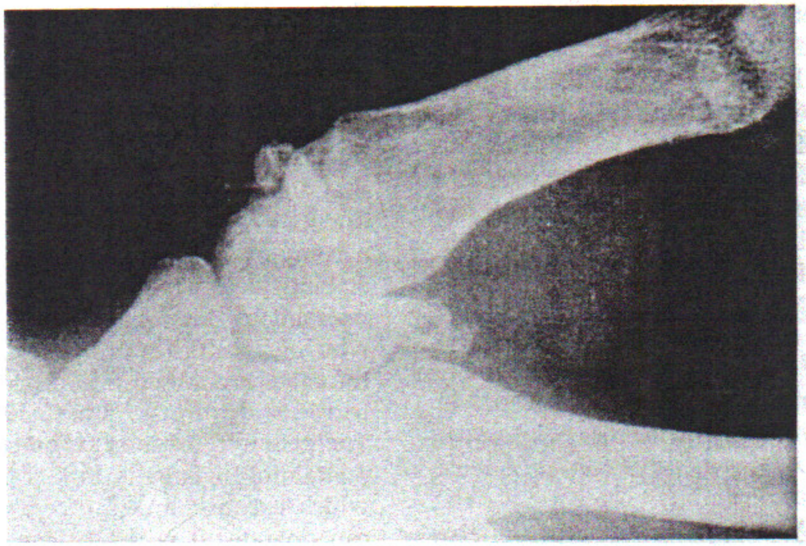

FIG 12–2.
End-stage osteoarthritis of the trapezial metacarpal joint of the thumb. Note the large radial and ulnar osteophytes with complete obliteration of the joint space.

the interphalangeal joint to move are recommended and will effect stabilization of the thumb in a functional position, allowing easier grasp with less discomfort. Intraarticular injections of a water-soluble corticosteroid solution can be helpful in selected cases but repeated injections should be avoided as they may hasten articular cartilage degeneration.

Surgical Management

The author generally recommends surgery to patients who have had unremitting pain in a splinted wrist to the extent that there is disruption in the activities of daily living, or with patients who are unwilling or unable to wear the splints but cannot function without them. Deformity without pain is a poor indication for surgery. At the present time, there are two categories of procedure for the salvage of the carpal metacarpal joints: arthroplasty and arthrodesis. In general, each of these procedures fulfills one of the requisites for good carpal metacarpal joint function. Arthroplasty, while allowing excellent movement, may not provide sufficient stability and could result in a weak pinch measured objectively, although the patient may actually experience an improved pinch depending on the level of preoperative morbidity. Arthrodesis on the other hand will provide excellent stability, but the patient will lose the ability to move the carpometacarpal joint, which will lead to arthritis at the thumb metacarpophalangeal joint and the scaphoid trapezoid joint.

Arthroplasty.—Over the years, there have been many approaches to treating carpometacarpal arthrosis. The range from a simple resection of the trapezium to interposition arthroplasty using various materials from rolled tendon graft (palmaris longus or fascia latae to synthetic materials, rolled Goretex to a total joint replacement with metal and polyethylene components). These allow for improved pinch with relatively painless movement. However, such procedures may be unsuitable for patients with very high occupational or life-style demands. Complications of total joint replacements include disarticulation, loosening, or fracture. Silastic implants have been associated with a late synovitis, which can cause cystic degeneration of the surrounding bone necessitating later removal and debridement.[10] Some recent modifications of the rolled tendon arthroplasty have been proposed to further stabilize the base of the carpometacarpal joint. One such modification is to include the use of one half of the flexor carpi radialis or abductor pollicis brevis securing the base of the thumb in a functional position and stabilizing this with a smooth percutaneous pin for internal fixation. This has shown to improve pinch and lessen metacarpophalangeal joint subluxation and swan-neck deformity of the thumb. This procedure is known as a suspensionplasty and is the procedure of the author's choice.

Arthrodesis.—Using the same surgical approach as the arthroplasty of the thumb interposition, the thumb is fused at 25 degrees of palmar abduction, 25 degrees of extension, and slight circumduction. Internal fixation is used to secure the fusion; occasionally, bone graft may be necessary to affect union. Thorough preoperative planning is necessary, if union is achieved, it will give the patient a stable, painless articulation, although the loss of movement is clearly evident.

CARPAL OSTEOARTHRITIS

Degenerative arthritis in the wrist is the final common pathway to destruction, usually stemming from previous injury. Such injuries may include fractures of any of the articular surfaces, ligamentous disruptions, and articular cartilage destruction. This may occur at the moment of impact or there may be a slow wear and tear on the articular surface caused by articular incongruity from fracture or by carpal ligament disruption in the wrist.

Characteristic findings of joint space narrowing, subchondral sclerosis, osteophyte formation, and degenerative cysts occur in two patterns, both described by Watson[17] and others. These are scapholunate advance collapse and triscaphe arthritis. Scapholunate advance collapse of the wrist occurs usually as a late sequela of scaphoid fracture malunion or scapholunate dissociation. Radioscaphoid arthritis begins at the styloid and progresses proximally (Fig 12–3). The radiolunate articulation is curiously spared. The scapholunate dissociation of these two bones widens and the capitate pushes down as a wedge between them, eventually reaching the radius. This results in severe radial-side pain and loss of movement. The best treatment is prevention. Timely treatment of scaphoid fractures and subluxations can forestall this process, although there is no guarantee of success. Radial styloidectomy as described by Barnard and Stubbins in 1948,[2] i.e., the removal of part of the radial styloid is a treatment for the radial-sided wrist pain. This technique can work quite well if radial scaphoid arthrosis is limited to the tip of the styloid, and can effect pain relief with preservation of motion. However, it will not arrest the progression of scapholunate advance collapse. Silastic carpal implants have been plagued by silicone synovitis and cannot be recommended at this time.

Selective limited intercarpal arthrodesis, i.e., radial scaphoid or capitolunate, can forestall the ultimate demise of the wrist, requiring total wrist fusion. Proximal row carpectomy can offer temporary pain relief and should be recommended for older people with lower wrist demands, although this, too, can degenerate.

Triscaphe arthritis pain is located at the base of

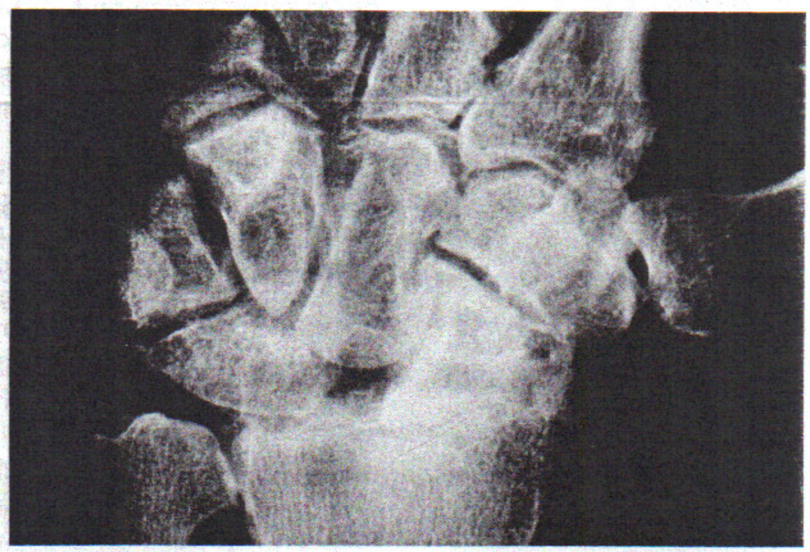

FIG 12–3.
Scapholunate advance collapse secondary to an old scapholunate dissociation with a rotatory subluxation of the scaphoid. Note the radioscaphoid joint space narrowing, sparing of the radiolunate articulation. Also evident is the proximal migration of the capitate through the old scapholunate diastasis.

the thumb. This can occur as an end result of local trauma and is expressed as pain and weakness to grip and pinch. It is best treated by splinting and local cortisone injection. Recalcitrant cases are treated by a local intercarpal fusion between the scaphoid, trapezium, and trapezoid.

INFLAMMATORY ARTHRITIS

There are many inflammatory disorders, but the prototype and most common disorder is rheumatoid arthritis. This is a slowly progressive disorder that affects virtually any joint in the body and can have a profound affect on the hand. Rheumatoid synovitis releases lytic substances in clearly defined patterns that destroy articular cartilage, as well as joint, capsule, bone, or tendon sheath. An understanding of these patterns will dictate the timing and indication for surgical and nonsurgical treatment. It is important to realize that the underlying disease can take three different forms—monocyclic, polycyclic, and progressive—but it is difficult to predict which pattern the patient will follow. One must also never forget that the primary treatment for this is medical, and surgery should be reserved for cases of progressive deformity, failure of medical treatment to stem synovitis, or impending tendon rupture. Barring these indications, a simple splint may be all that is necessary. One must also avoid being judgmental with these patients, as many of them, despite apparent severe deformity, retain function and may not require any surgical reconstruction.

Synovitis

In the wrist, hypertrophic rheumatoid synovium may invade the radiocarpal compartment, the distal radioulnar joint, the dorsal extensor compartment, or the flexor tendons across the carpal tunnel. Synovitis is easier to detect on the dorsum of the wrist as the skin in that area is subcutaneous tissue or thinner than on the volar aspect. This tenosynovitis begins beneath the extensor retinaculum on each of the extensor compartments and extends distally over the dorsum of the hand and envelops the extensor tendons of the wrist and the fingers (Fig 12–4). Lysosomal enzymes are released that digest and weaken the dorsal tendons and wrist ligaments and directly invade the tendons themselves, mechanically weakening them. If left unchecked, the synovitis can cause tendon rupture and loss of dorsal support for the wrist, creating a collapse deformity as the dorsal suspensory ligaments of the wrist fail. Involvement of the distal radioulnar joint with infiltrative rheumatoid synovium will weaken the restraining ligaments around the distal ulna and also the extensor carpi ulnaris, causing the carpus and the distal radius to sublux volarly creating a relative dorsal subluxation of the distal ulna. The synovitis will also sculpt the distal ulna into a sharp point dorsally (Fig 12–5). This is known as caput ulnae syndrome, and will now be discussed in greater detail.

FIG 12–4.
Dorsal tenosynovitis, commonly seen as an early manifestation of rheumatoid arthritis.

Tenosynovitis

The extrinsic extensor tendons of the wrist and hand cross the carpus but do not insert into it. Dorsally, each tendon goes in its own compartment; volarly, all the finger flexors course along with the median nerve and the flexor pollicis longus through the carpal tunnel and are covered by the transverse carpal ligament. All these tendons are covered by a ten-

FIG 12–5.
Classic presentation of a caput ulnae syndrome in moderately advanced rheumatoid arthritis. Note the osteophytes emanating from the distal ulnar head. The joint collapse affecting both radiocarpal and midcarpal joints are evident. Note the ulnar carpal impingement and the generalized osteopenia.

don sheath, which assists in nutritive and gliding functions of the tendon. Rheumatoid arthritis causes proliferation of the synovial tissue with copious amounts of synovial fluid, rich in lysosomal enzymes, which fill the synovial sheaths. Eventually, this hypertrophic synovium assumes the texture of "sticky rubber" and invades the tendon tissue itself, resulting in tendon rupture if left unchecked. Dorsally, the process is usually obvious, as the skin is quite thin. The protuberances, which are easily seen and palpated, have been occasionally mistaken for ganglion cysts early in the disease. Volarly, the process is more insidious and one may not be aware of the presence of the disease until the tendon rupture has already occurred. A high index of suspicion is necessary to avoid disaster. Interestingly, tenosynovectomy can be curative even though the tendons are grossly attenuated. Tendon ruptures are uncommon after tenosynovectomy.[12] On the volar side, tenosynovectomy is accomplished with the release of the carpal tunnel. This is frequently necessary because the patients present with concomitant carpal tunnel syndrome.

Tendon Ruptures.—Flexor and extensor tendons crossing the wrist are all-too-frequent victims of the relentless tenosynovitis that slowly destroys them. This may occur as a result of direct invasion by rheumatoid pannus or through lysosomal enzymes that digest them. Sharp bony prominences, such as of the ulnar head, Lister's tubercle, or the scaphoid tubercle, form a mechanical shearing device that assist in this process. Digital extensor tendons crossing over the caput ulnae are affected most commonly. Ruptures usually affect the ulnar digits first and progress radially. Clinically, this can manifest suddenly and without pain. The extensor pollicis longus can be affected independently.

Treatment.—The best treatment is prevention. Tenosynovectomy can be curative and is of an urgent nature especially if the patient has begun to rupture some of these tendons. Such tendon ruptures must be distinguished from tendon subluxation and from the possibility of a radial nerve palsy secondary to rheumatoid tissue infiltration around the radial nerve. This can be evaluated the "tenodesis effect." If the digits cannot be extended at the metacarpophalangeal joints by flexing the wrist, then chances are the tendons have been ruptured.

In the early stages of the disease, the tendons can be repaired in a side-to-side fashion to intact extensor tendons. Direct end-to-end repair may work in very early stages but will become impossible later on. If all the extensor tendons have ruptured on the dorsum, reconstruction becomes increasingly difficult and will require a tendon transfer from the volar side, usually a digital flexor. Flexor tendon ruptures are much more difficult to deal with. Tendon transfers or grafts or secondary reconstructions may be necessary as direct repair is usually impossible. Fusions of distal interphalangeal joints may be required where a profundus tendon rupture becomes irreparable. Again, prevention is key here.

Wrist Architecture

Collapse of wrist architecture occurs in characteristic patterns in rheumatoid arthritis. These patterns are governed by the close proximity of the synovial pouches to the supporting wrist ligaments. Collapse of the joint is also a result of articular cartilage and subchondral bone erosion, which may also be significant. These concepts are well illustrated by the distal radioulnar joint. Synovitis in the distal radioulnar joint destroys the joint capsule, thinning it distally, and grossly distending and thinning the triangular fibrocartilage complex. In caput ulnae syndrome, the head of the ulna becomes grossly deformed by the destruction of the articular surfaces, and as indicated previously, a relative dorsal subluxation of the ulna occurs, exposing a razor-sharp surface dorsally to the extensor tendons coursing over it. Volar subluxation and relative supination of the carpus on to the distal radioulnar joint occurs, which increases the dorsal prominence of the ulna. Pain, weakness, and loss of function with loss of rotation are common, as is limitation of wrist dorsiflexion.

Other areas of involvement include the radiocarpal joint where the intercarpal collapse patterns predominate. Destruction of articular cartilage in the radioscaphoid and radiolunate articulation will result in joint space narrowing, as evident on x-ray studies. Insufficiency of the radioscapholunate ligament can cause rotatory subluxation of the scaphoid and carpal malalignment. This will eventually lead to bony ankylosis, which may or may not be painful to the patient. In addition, the distal carpal row rotates radially along with the metacarpals giving rise to the "zig-zag" deformity of the digits. The carpus can migrate ulnarly as the radio lunate ligament and radial triquetral ligaments fail. Subchondral collapse of the scaphoid fossa of the distal radius can cause proximal migration of the scaphoid as well (Fig 12–6). Volar collapse of the wrist in a unidirectional fashion can be seen as a result of failure of all the volar radial carpal ligaments. Proximal migration of the capitate through a scapholunate diastasis is a direct result of weakening of the interosseous scapholunate ligament. Erythema, pain, and swelling are the predominant physical symptoms. Loss of grip and dexterity follow. At one end of the spectrum, stiffness with painful ankylosis, crepitation, and loss of flexion/extension may result. At the other end, gross instability can accompany volar collapse.

FIG 12–6.
Advanced rheumatoid arthritis in the wrist and the metacarpal phalangeal joints with the classic zig-zag deformity of the metacarpal phalangeal joints and the complete collapse of the wrist joint, most pronounced in the radiocarpal articulation. Note the massive destruction of the distal radius.

Reconstruction

Reconstructive options can be divided into two groups: soft tissue and bone-joint procedures.

In the soft tissue procedure, the first option is synovectomy. This is usually considered in patients early in the course of the disease who, after a period of about 6 months of medical therapy, have persistent pain, swelling, and loss of function as a result of inflammation. There is usually little or no joint or bony collapse. Removal of inflammatory synovium is not a permanent solution, but a synovectomy may bring about pain relief and delay the joint collapse associated with capsular distention and weakening. The procedure is performed through a dorsal approach in conjunction with a tenosynovectomy. In closure, the dorsal wrist capsule can be augmented by a slip of extensor retinaculum to reinforce these ligaments.[7] Patients usually regain a strong sense of security and grip and do not mind the relative increase in stiffness after the procedure. The bowstringing of the extensor tendons that may follow surgery can be limited by retaining approximately one third of the extensor retinaculum. Recently, the arthroscope has been employed to effect a synovectomy of the wrist with minimal distortion of the soft tissue envelope. This can be helpful if there has been no tendon involvement. Volar synovectomy of the wrist is more difficult but may be used in conjunction with carpal tunnel and volar tenosynovectomy.

The use of tendons to reconstruct intercarpal articulation has only fair results. This is because of two reasons. First, unlike in posttraumatic situations, the carpal bones themselves are extremely osteopenic, lessening the hold of soft tissue restraints on the bone; second the progressive nature of the disease will ultimately cause a weakening of these transplanted tendons.

Despite the progressive appearance of joint destruction seen on x-rays, patients with rheumatoid wrist involvement retain excellent function for a long period of time, mainly because the process occurs so slowly that the patients are able to adapt their activities of daily living. Early on, bony procedures will focus on the distal ulna. Surgical attempts to relocate the distal ulna are fraught with problems because the carpus may be contracted so that pulling it out is impossible. In this setting, shortening of the ulna, hemiexcision of the radial side of the ulna leaving the ulnar styloid intact, or excision of the distal 1 cm of ulnar head may be considered (Darrach procedure).[13] Although the Darrach procedure has lost favor in the reconstruction of post-traumatic radial ulnar joint problems especially in younger patients, in older rheumatoid patients the Darrach procedure will afford the patient increased movement and less pain, and remove the risk of extensor tendon ruptures. There have been many attempts to reconstruct the ulnar head with a Silastic prosthesis to support the ulnar carpus. While theoretically this is sound, and some patients can achieve good results, the technique has had its problems with fragmentation and silicone synovitis. In general, a well-performed Darrach procedure is all that is necessary in this setting to achieve good results.

Arthroplasty/Arthrodesis

As wrist disease progresses and the pain and instability become more prominent, one needs to consider performing an arthroplasty or an arthrodesis. Arthrodesis will create a strong, painless wrist devoid of motion. This can be problematic if the patient has another ankylosed joint in that extremity, a contralateral wrist fusion or ankylosis, or a desire to maintain wrist movement. Such patients may be candidates for arthroplasty. This has been performed with varying degrees of success with either soft interposition or Silastic endoprosthesis. Short-term results appear promising with these techniques. However, over the long term they have proven to be quite problematic. Silastic endoprosthesis can fracture and cause silicone synovitis. Arthrodesis is a final common pathway in these patients although many techniques have been described. The use of one or two intermedullary pins with or without the use of bone grafts has been advocated. The pins may be placed into the space between the 2–3 and 3–4 intermetacarpal spaces or a single stout Steinmann pin may go up the axis of the third metacarpal and up the intermedullary space of the radius (Fig 12–7). An oblique pin is placed temporarily to control rotation. These procedures force the wrist into a neutral position with respective flexion-extension axis. This is the best position for a single-wrist arthrodesis. In a bilateral case, a person may have his wrist flexed 5 to 10 degrees to facilitate hygiene. Fusion is readily achieved and pseudoarthrosis is rare. If there is concern about bilateral arthrodesis, a Swanson wrist arthroplasty may be performed on the dominant side.[1]

FIG 12–7.
A well-fused radiocarpal articulation. Note the excision of the distal ulna and the metacarpal phalangeal implant arthroplasties.

FRACTURES OF THE DISTAL RADIUS

Perhaps the most prominent hallmark of the aging wrist is osteopenia resulting from osteoporosis. This age-related thinning out of cortical and cancellous bone is an entity whose etiology remains obscure. It is well known that this disorder is probably an accelerated resorption of bone over time in the face of a normal rate of bone formation. This affects cancellous bone more profoundly than cortical bone and as such, the cancellous metaphyses of bone are more susceptible to fracture that the diaphyseal regions. This explains the preponderance of fractures in the proximal and distal femur, humerus, vertebral body, and in the distal radius of this age group. Injuries to the distal radius were described over 100 years ago by Abraham Colles, who felt that these deformities—once developed—were essentially incurable, but some function could be achieved regardless over time. These assumptions have been held to be true until very recently as better reporting brings to light the true nature of the long-term problems associated with these injuries. Until recently, the classifications of injuries to the distal radius have simply been relegated to eponyms, i.e., Colles', Barton's, and Smith's. These classifications have significant problems. Over the past 25 years, there have been multiple attempts to classify these injuries based on angulation, displacement and position of the fracture, displacement of the articular surface, the mechanism of injury, the number of fracture parts, and the axis of displacement (either on anteroposterior or the lateral planes). Recently, most useful classifications by Melone[11] and the AO group[4] clearly define the location and position of articular fragments, and will help predict a method of treatment and prove useful for prognosis.

Prognostic Factors

It has been clear that the following factors play a key role in determining a poor prognostic outcome[6]: (1) reversal of the normal palmar tilt of 11 degrees; (2) joint incongruity greater than 3 mm; (3) radial shift of the distal radial fragment greater than 2 mm; (4) flattening of the normal articular shape of the distal radius seen on the anteroposterior x-ray. Al-

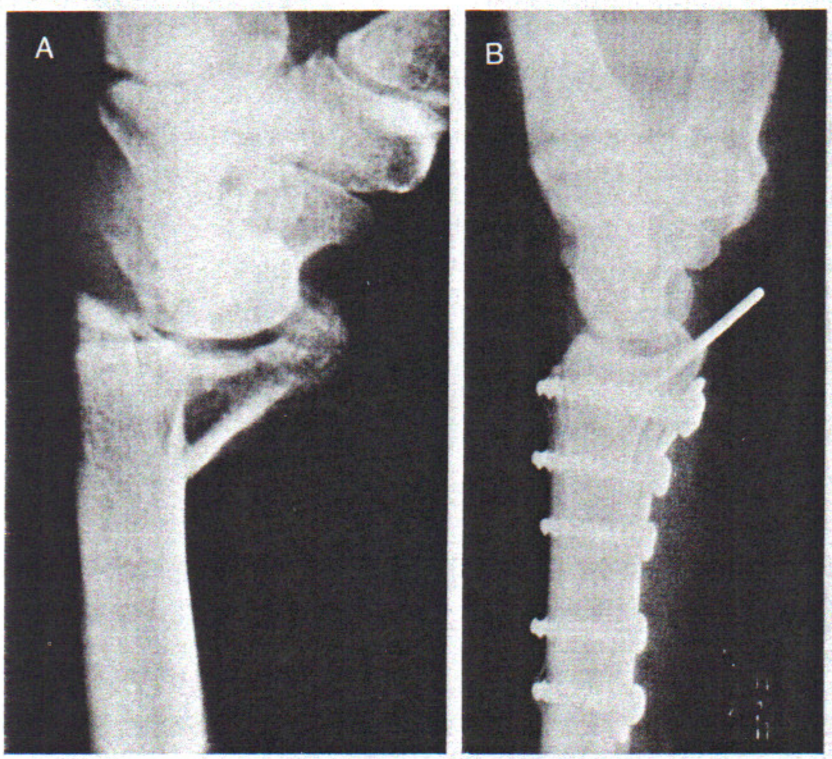

FIG 12–8.
A, comminuted fracture of the distal radius. Note the volar cortex of the distal radius and the volar displacement of the carpus. **B,** after open reduction internal fixation with a volar plate and screws and a K-wire, with reduction of the radiocarpal articulation.

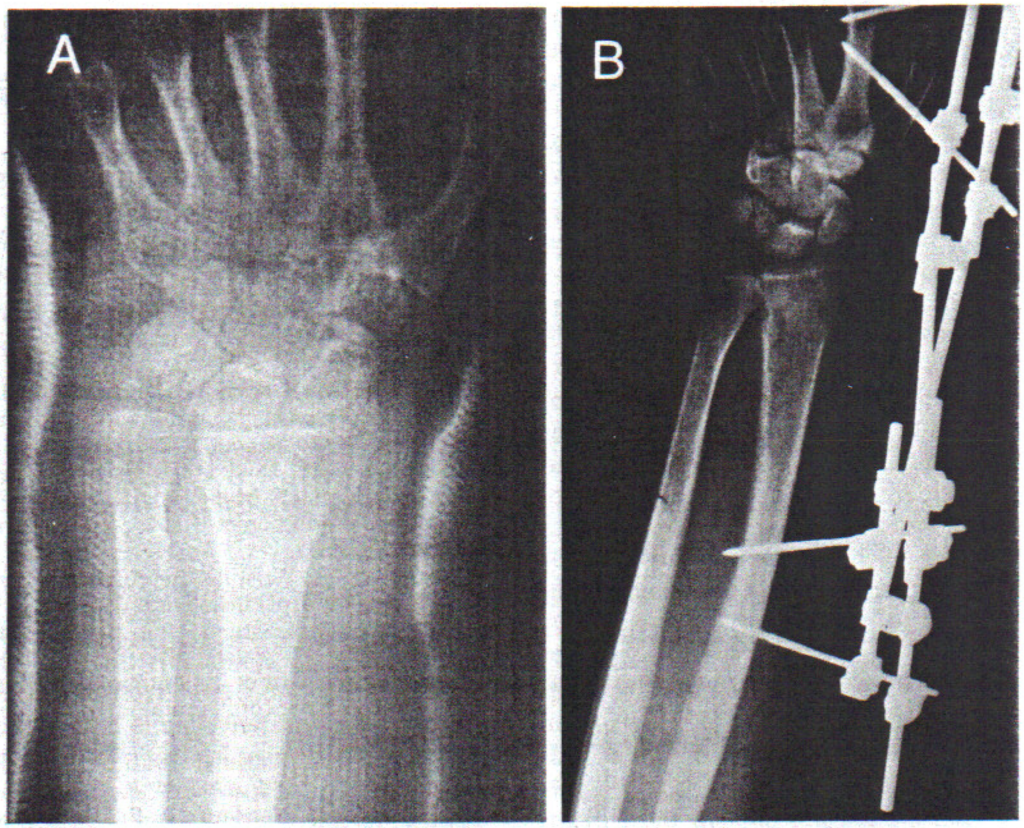

FIG 12–9.
A, comminuted fracture of the distal radius with persistent shortening as a result of settling of the fracture. If left untreated, this patient would develop an ulnar carpal impingement. **B,** after external skeletal fixation of this fracture, length of the distal radius has been maintained; however, open reduction internal fixation is still required because of persistent articular incongruity of the distal radius.

though these concepts have been used to treat high-energy fractures of the distal radius in young patients, similar patterns exist in osteopenia fractures of the elderly. However, the demands of these patients are low, and long-term problems of osteoarthritis are less of an issue.

Treatment

Treatment in a long- and short-arm cast or sugar tong splint will suffice in extraarticular, noncomminuted, or nondisplaced fractures. However, if any of these conditions are not met, redisplacement after closed reduction is common and will require further treatment such as percutaneous pinning, pins and plaster, external skeletal fixation, or open reduction internal fixation with pins, screws, or plates and screws. Occasional combinations of the above techniques are necessary to achieve a stable reduction. Recently, there has been an increasing trend towards external skeletal fixation and/or open reduction internal fixation (Fig 12–8). External fixation has the advantage of counteracting muscle forces that tend to compress the fracture. Also, the distraction tends to pull the comminuted fragments into place by tightening up the joint ligaments and soft tissues sleeve around the bone (Fig 12–9). Pin tract infections and injury to the radial nerve are known complications of this technique, but with attention to detail, this can be avoided. Other complications include postoperative long-term stiffness, median neuropathy, flexor tendon rupture, and tendon adherence, as well as posttraumatic arthritis.

STROKE AND BRAIN INJURY

A myriad of clinical features can be seen with patients who are hemiplegic owing to a stroke or brain injury. The wrist is an active participant in this disease complex. It must be kept in mind that hemiplegic patients retain nearly normal sensitivity on the affected side; however, this affected side may be partially insensate but can still be used as a helper hand. Depending on degree of neurologic injury, patients may have variable use of their affected hand. Ultimately, sensibility of the hand will determine what kind of use there will be. The hand surgeon is frequently called upon to intervene in these patients because of spasticity and contracture that may ensue. Frequently, in these patients the hand is balled into a tight fist and there may be marked flexion contractures in the wrist of greater than 70 degrees. This frequently can interfere with hygiene. Hand function may be absolutely impossible. One also needs to consider that elbow contractures are also quite common and need to be considered in the comprehensive care of the patient. Furthermore, prolonged flexion of the wrist will cause pain owing to joint contracture and median nerve compression. Surgical procedures to lengthen or cut tendons across the wrist will afford patients pain relief. Sometimes stretch therapy can be useful in early stages if the wrist can be brought out into extension easily; however, if a firm contracture has already developed, this will not be helpful. Occasionally, a procedure known as the flexor origin slide—where the origin of the flexor tendons can be sectioned at the elbow, and the shortened muscle tendon units allowed to drift into the forearm—can be helpful. This flexor origin slide has been useful in the management of wrist contractures in stroke patients.

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