Current Concepts Review

Carpal Instability

BY JULIO TALEISNIK, M.D.*, IRVINE, CALIFORNIA

From the Department of Surgery (Orthopaedics), University of California at Irvine, Irvine

Before Röntgen’s discovery of radiographs, only injuries of the wrist that resulted in gross distortion of osseous landmarks were recognized. The use of radiographs and other diagnostic techniques has expanded the spectrum of treatable injuries to include conditions that, until a few years ago, were unknown or extremely rare. It is now universally agreed that there is a spectrum of carpal injuries that ranges from sprains to major fractures, dislocations, and fracture-dislocations. Within this spectrum, carpal instabilities, which were first mentioned by Gilford et al.16 and later were described in association with scaphoid fractures by Fisk14, have assumed increasing importance.

In 1972 Linscheid et al.28, and in 1975 Dobyns et al.12, wrote landmark articles on carpal instability. They defined traumatic instability, described radiographic findings, provided a working classification, suggested a mechanism of injury, and proposed the first approach to treatment. Most subsequent reports on this subject have only refined or expanded on the conclusions of these authors.

Anatomy

The proximal surface of the carpus is an oblong condyle that articulates with the composite surface of the radius and the triangular fibrocartilage. The structure is not a fixed, immutable condyle, but rather is a structure of variable geometry that changes shape to accommodate to the requirements for space, during motion, between the forearm and the hand22. These changes are possible because the carpal condyle, which consists of eight bones that are arranged in two rows, creates a multifaceted articulation to meet the need for mobility and stability of the wrist.

The slopes of the articulating surface of the radius and the shapes of the carpus define vectors that fall in predetermined directions when the wrist is loaded58. In particular, the articular surface of the distal part of the radius slopes in a palmar and ulnar direction, creating a palmar-ulnar vector under load. However, the articular surface is supported by a ligamentous system that prevents unidirectional migration of the carpus59.

There are two major groups of ligaments of the wrist:

1. extrinsic ligaments, which course between the carpal bones and the radius or the metacarpals, and intrinsic ligaments, which originate and insert in the carpus77-83. These ligaments were named for the bones from which they originate and into which they insert. The palmar radiocapitate, palmar radiolunate, palmar radioscapohamate, dorsal radiocarpal, and dorsal intercarpal ligaments, as well as the ligamentous complex in the ulnar carpal space77, are particularly important. Biomechanically, the extrinsic ligaments are stiffer, while the intrinsic ligaments are capable of greater elongation before permanent deformation occurs30.

The presence of a collateral ligament system of the wrist, of the traditional construct, has been questioned. In 1979, Kauer stated that the unique range of motion of the wrist “excludes collateral ligaments as components of the ligamentous apparatus of the wrist”21. The function of a true collateral structure, as is seen in hinge (ginglymoid) joints, is not possible in a joint like the wrist, which has the anatomical appearance of a condylar or trochlear articulation but the actual function of a multiaxial enarthrosis22,57. Collateral ligaments would be useful only if radiocarpal motion were limited to flexion and extension. When ulnar and radial deviation are added, a static collateral ligament would, in effect, restrain lateral and medial angulatory displacements.

Kauer proposed that the wrist has an “adjustable collateral system” of muscles acting as true collateral support: the extensor carpi ulnaris for the ulnar side of the wrist and the extensor pollicis brevis and abductor pollicis longus for the radial side. Frequently, the volar part of the capsule of the wrist has an area of weakness, called the space of Poirier, between the main ligamentous structures that are attached proximally on the lunate and distally on the capitate.

Kinematics

In general, no tendons are directly attached to the carpus. There are three systems of tendons that cross the wrist: the extrinsics of the fingers, which cross the center of the wrist and exert minimum abduction-adduction moment on the joint (the center of rotation of the wrist lies within the head of the capitate)22; the flexors and extensors of the wrist, which surround the periphery of the joint and allow positioning of the wrist without motion of the fingers; and the
tendons passing around the radial styloid process, which can exert marked radial deviation. Within this system, the proximal carpal row behaves as an intercalated segment in a three-joint link system. As such, the system would tend to collapse under compressive load were it not for the presence of the scaphoid across the mid-carpal joint. An analogy has been made between this mechanism and a slider-crank control, in which a three-bar linkage (represented by the radius, lunate, and capitometacarpal links) is stabilized by the scaphoid "crank".

Navarro proposed an entirely different concept — that of the vertical or columnar carpus. He proposed that there are three longitudinal carpal columns; a lateral column (the scaphoid), a medial column (the triquetrum), and a central flexion-extension column (the lunate and the entire distal carpal row). Within this system, the lateral column (the scaphoid) functions as a stabilizing rod across the lunatocapitate joint. It is also responsible for palmar flexion of the proximal carpal row during radial deviation, as the scaphoid palmar flexes to accommodate to the shrinking space between the trapezium and the radial styloid process. When the scapholunate joint is dissociated, the absence of this function allows palmar flexion of the scaphoid to coexist with dorsiflexion of the lunate and triquetrum in the same proximal carpal row.

Similarly, during ulnar deviation, shortening of the distance between the hamate and the styloidy process is facilitated because the triquetrum migrates distally on the hamate and dorsiflexes simultaneously. Because of the relative palmar position of the triquetral facet of the hamate, this distal progression of the triquetrum forces the hamate in a palmar direction. The axis of the lunate also becomes palmar in relation to the capitate. Compressive forces from the capitate on the lunate then assist in rotating the lunate into dorsiflexion. When there is a lunatotriquetral dissociation, this action can no longer be transmitted to the lunate. This explains how a dorsiflexed triquetrum can coexist with a palmar flexed lunate-scaphoid unit within the same proximal carpal row. These scaphoid-induced and triquetrum-induced rotations allow the proximal carpal row to function as an intercalated segment. Thus the carpus has variable geometry, maintaining the useful space or distance between the radius and the distal carpal row. Recently published experimental data supported this concept and denied the validity of the columnar theory of carpal function.

In 1981 Lichtman et al. observed that a columnar concept fails to account for transverse, or perilunate, instability, as well as for clinical patterns of transverse mid-carpal and proximal carpal instabilities. They proposed the oval-ring theory, according to which the carpus is a transverse ring, formed by the distal and proximal carpal rows and joined by two physiological links — one radial (the mobile scaphotrapezial joint) and the other ulnar (the rotatory triquetrohamate joint).

Weber's investigations have contributed to the understanding of the biomechanics of the wrist and have clarified the role of the triquetrum. He emphasized that the carpal intercalated system is controlled through both ligamentous and contact-surface constraints. The contact surface provides stability throughout motion, while at the same time transmitting loads. This is a kinetic, rather than simply a kinematic, concept, incorporating transmissions of longitudinal load into the abstract analysis of carpal motion without load. Weber thought, as did Navarro before him, that it is useful to think of the wrist in terms of longitudinal columns when attempting to understand control of intercalated segments through joint contact. He believed that there is a force-bearing column, composed of the distal part of the radius, the lunate, the proximal two-thirds of the scaphoid, the capitate, the triquetrum, and the articulation of the carpus with the second and third metacarpals. The function of the force-bearing column is to transmit forces that are generated by the hand to the forearm.

According to Weber, a second control column consists of the distal part of the ulna, the unocarpal complex, the triquetrum, the hamate, and the bases of the fourth and fifth metacarpals. The transmission of longitudinal force by this ulnar column is limited because the triangular fibrocartilage has greater compliance with applied loads. Instead, compressive forces on the ulnar column are deflected through the rigid, planar hamate-capitate articulation of the central force-bearing column. In addition, the configuration of the hamate-triquetrum joint is well suited to provide rotational control.

The third column is the thumb-axis column, which includes the distal third of the scaphoid, the trapeziotrapezoid joint, and the base of the first metacarpal. This column acts a support for the base of the thumb, allowing independent function of that digit. Compressive loads on this column are also deflected to the central force-bearing column, along the intact scaphoid, and across the trapezium, trapezoid, and scaphoid to the capitate.

Unlike the carpal-ring and variable-geometry concepts, the columnar theories account for the presence of forces and loads that are, by necessity, transmitted from the hand to the forearm in a longitudinal direction.

Carpal Instability

Dobyns et al. defined traumatic instability of the wrist as "a carpal injury in which loss of normal alignment of the carpal bones develops early or late". They recognized four major types of carpal instability: dorsiflexion, palmar flexion, ulnar translocation, and dorsal subluxation. Dorsiflexion instability, which is the most frequent, is present when the lunate has rotated into dorsiflexion, as seen on lateral radiographs. The capitate displaces dorsal to the long axis of the radius, producing a zigzag radiolunatecapitate alignment that is called dorsal intercalated-segment instability (DISI). The intercalated segment is the lunate, as identified on lateral radiographs. The opposite pattern, palmar intercalated-segment instability (VISI), is characterized by palmar flexion of the lunate. In the third type of carpal instability, ulnar translocation, the carpus shifts ulnarward. The fourth type, dorsal subluxation, is commonly seen after
a malunited fracture of the radius associated with reversal of the normal palmar tilt of the articular surface. Although Dobyns et al.\textsuperscript{12} considered an opposite, volar type of carpal subluxation to be theoretically possible, it was not until after their study was published that isolated cases were reported\textsuperscript{3}.

These carpal abnormalities, which can be clearly recognized on routine radiographs by the loss of normal alignment of the carpal bones, have been called static\textsuperscript{49,50}. There is a second type of carpal instability for which the routine radiographic findings are within normal limits. With this type of instability, the patient can voluntarily change the carpal alignment from normal to abnormal and the reverse.

Sometimes the instability can be reproduced by manipulation only; again, all other ancillary tests, with the possible exception of bone scans, are normal. This form of instability is called dynamic, and it may occur between the scaphoid and the lunate, between the lunate and the triquetrum, or between the carpal rows at the mid-carpal joint.

The most common carpal instability is secondary to ligamentous disruption between the scaphoid and the lunate, the second most common instability is that between the lunate and the triquetrum, and the third most common is dynamic mid-carpal instability. Ulnar translocation rarely results from injury, but it is frequent in wrists that are affected by rheumatoid arthritis. Carpal instability secondary to malunion of a fracture of the distal part of the radius is also common.

Anatomically, there are three types of instability: lateral instability, which usually occurs between the scaphoid and the lunate; medial instability, which occurs between the triquetrum and the lunate or between the triquetrum and the hamate (mid-carpal instability); and proximal instability, which occurs when the abnormal carpal alignment is secondary to an injury of the radius or to a massive radiocarpal disruption (dorsal carpal subluxation, mid-carpal instability secondary to malunion of the distal part of the radius, and ulnar translocation)\textsuperscript{49,51,53}.

The patterns of instability that result from ligamentous disruption in the proximal carpal row — that is, between the scaphoid and the lunate or between the lunate and the triquetrum — include scapholunate dissociation, which results in dorsal intercalated-segment instability, and lunotriquetral dissociation, which leads to volar intercalated-segment instability. These injuries are forms of dissociative carpal instability\textsuperscript{11}.

Non-dissociative carpal instability also results in dorsal and volar intercalated-segment instability, but it is not associated with a ligamentous injury in the proximal carpal row; all three major bones continue to function as a unit. Non-dissociative carpal instabilities include dorsal carpal subluxation, mid-carpal instability in which rotation of the bones in the proximal carpal row leads to dorsal or volar intercalated-segment instability, volar carpal subluxation (which is very infrequent), and some ulnar translocations.

Mechanism of Injury

Assessment of the laxity of the joints of different individuals is important in determining the outcomes of otherwise identical injuries to the wrist\textsuperscript{7}. A fall on the outstretched upper extremity when the wrist is in dorsiflexion may result in a fracture in some patients and a dislocation in others. Hypermobility of the joint is frequent in patients in whom an injury elongates or partially or completely tears a ligament. In addition to the variation in behavior of ligaments among different people, it has been suggested that there is a qualitative difference in yield strength of different ligaments in the same individual\textsuperscript{26}. According to this thesis, the weakest ligaments are in the radial and palmar quadrants of the wrist\textsuperscript{26}. This may explain the presence of clinical instability without radiographic, arthrographic, or surgical evidence of a torn ligament. As is true for carpal dislocations and fracture-dislocations, the point of application, magnitude, and direction of the force of injury, and the position of the hand at the time of impact, are important in determining the resulting carpal instability.

Most frequently, injuries follow compressive loading of the wrist in some degree of dorsiflexion. Rotation of either the forearm or the wrist itself is frequently present. In a study of carpal dislocations and fracture-dislocations, Mayfield et al.\textsuperscript{35} loaded the wrists of cadavers in extension, ulnar deviation, and intercarpal supination. The resulting sequence of injury, which they called progressive perilunar instability, included four stages. At the end of stage I, a scapholunate diastasis, the most frequent type of carpal instability, was produced. Progression of the loading led to stage II, dorsal dislocation of the capitate. In stage III, the triquetrum gradually dislocated from the lunate, resulting in triquetrolunate diastasis or an avulsion fracture of the triquetrum. Stage IV was typified by dislocation of the lunate, the greatest degree of perilunate instability.

Clinical evidence has suggested that loading on the ulnar side of the carpus, with the carpus hyperpronated, results in triquetrolunate injury\textsuperscript{42}. In addition, in younger patients who have ligamentous laxity, a malunited fracture of the distal part of the radius that results in loss of normal palmar tilt of its distal articular surface may allow immediate or progressive carpal subluxation. This subluxation may occur at the level of either the radiocarpal joint (dorsal carpal subluxation) or the mid-carpal joint (mid-carpal instability secondary to a malunited fracture of the distal part of the radius)\textsuperscript{52}.

Diagnosis

The diagnostic process starts with documentation of the mechanism of injury and of the patient's complaints. For patients who have dynamic instability, so-called trick motions or snaps must be observed. Any localized tenderness should be elicited. The clinical findings must be kept in mind, because frequently these patients have normal findings on routine radiographs. Only after the routine radiographs have been seen to be normal can dynamic instability and tenderness be investigated further. To assess dynamic instability, radiographs are made both before and after a position of instability has been assumed\textsuperscript{52} or the carpus has...
been manipulated. To assess tenderness, radiographs are made with metal markers at the site of the tenderness.

Additional documentation can be obtained by injecting a small amount of an anesthetic agent into the tender joint and recording changes in the pattern of pain, mobility, and grip strength. Manipulation of the scaphoid by the examiner may reproduce the patient's sensation of instability or even cause subluxation of the proximal pole of the scaphoid (the Watson test)\textsuperscript{52}. If the ulnar side of the carpus is involved, triquetrolunate ballottement\textsuperscript{42} or mid-carpal manipulation\textsuperscript{31} is performed.

The initial radiographic examination is tailored to the patient's complaints and clinical findings. On a posteroanterior radiograph, three major features are evaluated sequentially\textsuperscript{7}: (1) the carpal arcs, which are usually concentric and which are traced along the proximal and distal surfaces of the proximal carpal row and the proximal surface of the distal carpal row; (2) the symmetry of the joint spaces; and (3) the shapes of the individual bones. Lateral radiographs are useful for the evaluation of radiolunotriquetral alignment and for the determination of angles between these bones and the scaphoid.

**Radiographic Findings**

**Scapholunate Dissociation**

For a wrist that has scapholunate dissociation, anteroposterior radiographs show a scapholunate gap that is wider than the scapholunate space in the opposite, uninjured wrist. This gap is usually more noticeable on an anteroposterior radiograph that is made with the wrist supinated than it is on the more usual posteroanterior radiograph (made with the wrist pronated). It is important to direct the x-ray beam parallel to the scapholunate joint. Moneim\textsuperscript{77} and Frot et al.\textsuperscript{15} described radiographic projections to accomplish this objective.

The cortical ring sign is produced by the cortex of the distal pole of the palmar flexed scaphoid as seen end-on\textsuperscript{39,12}. The scaphoid is foreshortened. The distance between the scaphoid ring and the proximal pole of the scaphoid is decreased to less than seven millimeters\textsuperscript{8}. These patients have lost the normal scapholunotriquetral correlation — a foreshortened (palmar flexed) scaphoid coexists with a quadrilateral (dorsiflexed) lunate, and the triquetrum is in a distal position (dorsiflexed) in relation to the hamate.

Negative ulnar variance has been found to be significantly more frequent in patients who have a post-traumatic scapholunate dissociation\textsuperscript{4,40}. At present, the biomechanical implications of this finding are conjectural.

Posteroanterior radiographs that are made with the wrist in ulnar deviation, in radial deviation, and with the application of longitudinal compressive load\textsuperscript{15} (with the fist clenched) may also show a widened scapholunate gap in the wrist that has scapholunate dissociation.

Lateral radiographs are valuable to assess the opposite rotations of the lunate and the scaphoid. When the scapholunate joint is dissociated, the scaphoid is palmar flexed, with its long axis perpendicular to that of the radius, and the lunate is dorsiflexed (dorsal intercalated-segment instability). The scapholunate angle, which normally ranges from 30 to 60 degrees and averages 46 degrees, increases to more than 70 degrees\textsuperscript{12-28}.

**Triquetrolunate Dissociation**

A posteroanterior radiograph of a wrist that has a fully developed volar intercalated-segment instability shows the scaphoid to be volar flexed and foreshortened. The ring sign is present, and the distance between the ring and the proximal pole of the scaphoid is decreased. However, unlike the case with scapholunate dissociations, the lunate is volar flexed and triangular. The triquetrum is dorsiflexed and distal in relation to the hamate. The distance between the ulnar head and the triquetrum is shortened (the Mayersbach sign)\textsuperscript{52}. The convex outline of the proximal carpal condyle, called the Shenton line of the wrist by Linscheid, is interrupted by a step-off between the lunate and the triquetrum.

Lateral radiographs show the lunate to be palmar flexed. If the triquetrum and the lunate can be identified, the normal triquetrolunate angle of approximately -16 degrees is converted to a neutral or positive angle\textsuperscript{39}.

**Ulnar Translocation**

Abnormal translation of the lunate in an ulnar direction is pathognomonic of ulnar translocation. McMurtry et al.\textsuperscript{33} described a reproducible method of measuring what they called the carpal-ulnar distance — that is, the distance between the center of rotation of the carpus, in the head of the capitate, and a line extending the longitudinal axis of the ulna distally. In normal wrists, dividing this distance by the length of the third metacarpal consistently results in a ratio of 0.30 ± 0.03. In wrists that have ulnar translocation, the ratio is smaller, indicating that the capitate and the lunate are translocated in an ulnar direction.

A similar method, using the lateral part of the radial cortex instead of the longitudinal axis of the ulna, has been proposed\textsuperscript{8}. According to the position of the scaphoid, two types of ulnar translocation can be seen\textsuperscript{32}. In Type I, the entire carpus, including the scaphoid, is displaced, and the distance between the radial styloid process and the scaphoid is widened\textsuperscript{32}. In Type II, the relationship between the scaphoid and the radius, and thus the distance between the scaphoid and the radial styloid process, remains normal, but the scapholunate space is widened.

The distinction between the two types of ulnar translocation is important, because the appearance of a wide scapholunate gap may lead to the erroneous diagnosis of scapholunate dissociation. If this happens, any attempt at stabilizing what appears to be a rotatory subluxation of the scaphoid will fail to correct the underlying problem, which is ulnar migration of the carpus\textsuperscript{52}. Ulnar translocation frequently is accompanied by volar flexion instability of the proximal part of the carpus.

**Dynamic Instability**

Dynamic forms of dorsal or volar intercalated-segment...
instability are secondary to loss of support across the ulnar half of the mid-carpal joint\textsuperscript{27}. Routine radiographs usually are considered normal, although the alignment of the radiocarpal link may have a palmar or dorsiflexion bias. Many patients who have dynamic instability can actively subluxate the wrist with the forearm pronated and the wrist in or out of ulnar deviation\textsuperscript{27}.

Diagnostic radiographs are made with the patient's forearm and hand pronated, elevated on a bolster, and placed against the radiographic plate, which is held vertically. The x-ray beam is directed horizontally across the wrist. The patient is then asked to reproduce the position of abnormal carpal alignment. (If the end-point of active motion that produces the subluxation is different from that just described, the radiographs should be made with the wrist in that position.) Lateral radiographs will show a volar or dorsal intercalated-segment instability, with loss of the alignment between the capitate and the radius that is normal for that patient\textsuperscript{52}. In most patients, this approach eliminates the need for cineradiographic studies.

Special Studies and Ancillary Procedures

Bone scintigraphy and arthrography — which, when deemed necessary, probably are best done in that order — are useful in the diagnosis of carpal instability. In patients who have carpal instability, the uptake of isotope is increased, probably secondary to hyperemia accompanying reactive synovitis. When a scan is negative, it suggests either that there is no injury or, more frequently, that the problem is minor and can be treated non-operatively. Because it is not specific, a positive scan should not be used alone in determining the diagnosis, but should be employed in conjunction with other tests. Triphase scans are preferable\textsuperscript{46}; when a posteroanterior image is positive, lateral and oblique images should be made as well\textsuperscript{52}. This helps to localize the carpal problem.

Arthrography is helpful in finding ligamentous tears. It is important that the flow of opaque material be followed in an image intensifier to find leaks and abnormal communications\textsuperscript{49}. Digital fluoroscopy has been used advantageously for the same purpose. Arthograms that are made by injecting all three major joints (radiocarpal, mid-carpal, and distal radio-ulnar) with contrast medium are helpful and sometimes obligatory\textsuperscript{44}. It is important to keep in mind that communications between the different compartments of the wrist are not necessarily the result of trauma, but may indicate the presence of age-related degenerative changes\textsuperscript{26}. Arthroscopy is valuable for direct visualization of the intercarpal joints\textsuperscript{52}.

Computed tomography is probably not useful in the diagnosis of carpal instability. Magnetic resonance imaging is promising, although its value and applications for the wrist have yet to be determined.

Treatment

Scapholunate Dissociation

Manipulation and closed pinning under cineradiographic control may correct a fresh scapholunate dissociation\textsuperscript{1}. In most patients, however, surgical visualization and repair of the torn ligaments, using dorsal and palmar incisions, is more reliable.

For a chronic scapholunate dissociation that is not associated with osteoarthritis, the technique of reconstruction of the ligaments by threading tendons through drill-holes in the carpal bones or the radius, or both, has proved to be unreliable and is very demanding technically\textsuperscript{48,20,41}. Instead, reattachment of the scapholunate ligament, which is usually torn from the scaphoid, can be attempted. The reattachment can be augmented by attaching tendinous or capsular tissue along the scapholunate space\textsuperscript{19}. A dorsal capsuloligamentodesis, as described by Blatt\textsuperscript{45}, also can be used instead of, or in addition to, the repair of the ligament. For a capsuloligamentodesis, a dorsal capsular flap, which is left attached to the radius proximally, is inserted in the distal part of the scaphoid to tether the distal pole dorsally, keeping the scaphoid from subluxating in a palmar direction.

Young adults who have pronounced systemic laxity of the joints, powerful grip strength, and a physically demanding occupation benefit from stabilization of the scapholunate by a limited arthrodesis between the scaphoid, the trapezium, and the trapezoid, as popularized by Watson and Hemptin\textsuperscript{47}. This procedure, as well as all other limited carpal arthrodeses, must preserve the size and outer shape of the fused unit and must not interfere with the relationship and alignment of the surrounding carpal joints. The long-term results of the procedure have thus far dispelled doubts regarding the wear and tear of joints neighboring the site of a partial carpal arthrodesis\textsuperscript{24,25}. However, the results have not been uniformly predictable\textsuperscript{47}. Not only is there residual limitation of motion, but in some patients the procedure has also been followed by weakness and pain during forced loading of the wrist in dorsiflexion.

Untreated chronic scapholunate dissociation commonly results in a pattern of osteoarthritis and subluxation that has been called scapholunate advanced collapse (SLAC)\textsuperscript{27}. Typically, degenerative changes occur in areas of abnormal loading, initially between the radial styloid process and the scaphoid and later in the unstable lunatocapitate joint, as the capitale subluxates dorsally on the lunate. The recommended treatment for this problem consists of replacement of the scaphoid with an implant and stabilization of the unstable mid-carpal joint through a mid-carpal fusion.

Lunatotriquetral Instability

The acutely symptomatic lunatotriquetral joint may be treated successfully by local injection of steroids and immobilization above to the elbow. If this approach fails or if the instability is chronic and disabling, the lunatotriquetral ligament can be repaired directly, with or without capsular or ligamentous augmentation\textsuperscript{48}. Where there is an ulnar-plus variant, especially if the triangular fibrocartilage is perforated, ulnar shortening is the procedure of choice. Lunatotriquetral arthrodesis may be used when the other tech-
niques are not feasible.\textsuperscript{34}

**Ulnar Translocation**

Surgical exploration of an acute ulnar translocation routinely discloses a massive dorsal and palmar tear of the capsule from the radius. Frequently, a previously unsuspected tear of the scapholunate ligament is present. Repair of the ligament, even when the injury is acute, is unreliable. Experience with the treatment of ulnar translocation in arthritic wrists,\textsuperscript{40} suggests that relocation of the carpus and maintenance of reduction by radiolucent arthrodesis may be a more reliable and satisfactory technique.

**Dynamic Volar and Dorsal Intercalated-Segment Instability**

A trial of non-operative management, including above-the-elbow immobilization with the elbow supinated, local injections of steroids, and administration of anti-inflammatory medication, is justified if the patient had not received such treatment previously, particularly if the patient is not physically demanding. However, for patients who are disabled by persistent or recurrent symptoms, stabilization of the mid-carpal joint through limited arthrodesis, capsuloligamentodesis, or tenodesis is justified.\textsuperscript{31,32}

**References**