CARPAL INSTABILITY

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Carpal instability is the term used for a group of conditions which results from injuries to the carpus, ranging from a simple sprain to a major fracture-dislocation. In the English literature Gilford, Bolton and Lambriniudi (1943) were the first to note the potential for instability, describing the wrist as a link joint which was stable under tension because of the position and size of the scaphoid bone, and in 1970 Fisk described carpal instability from nonunion of a scaphoid fracture as a zig-zag or concertina deformity. Linscheid et al (1972) proposed a classification and offered the definition "carpal injury in which a loss of normal alignment of the carpal bones develops early or late".

INCIDENCE

In 1975 Dobyns et al reviewed their own experience and that of the Böhler Clinic and reported that 10% of all carpal injuries resulted in instability. Jones (1988) studied a consecutive series of 100 wrist injuries with no radiological evidence of fracture; he took special radiographs of the wrist including a clenched-fist view. In 19 patients there was an increase in the scaphoid-lunate gap and five of these had scaphoid-lunate instability. Kelly and Stanley (1990) reviewed 98 consecutive wrist arthroscopies and identified many ligamentous injuries, findings that were confirmed by Sennwald, Fischer and Jacob (1993) who carried out arthroscopy on 41 injured wrists and found at least one ligamentous lesion in 25% and two or more distinct lesions in 75%.

The incidence of carpal instability in association with other injuries is unclear. In a large series of fractures of the distal radius, Tang (1992) found radiological evidence of carpal instability in 30.6%. Nakamura et al (1991), however, performed arthroscopy on the wrists of a group of patients with ununited scaphoid fractures and found that most did not have serious ligamentous injuries.

PATHOMECHANICS

Understanding carpal instability requires a thorough knowledge of the anatomy and mechanics of the carpus. The distal row of bones, the trapezium, trapezoid, capitate and hamate, forms a stable platform upon which the metacarpals ride and there is very little motion between these bones. Similarly, the distal radius and ulna, although they move in pronation and supination, are essentially stable. The proximal row of the carpus, however, is an intercalated segment with no muscle insertions; its stability depends entirely on the capsular and interosseous ligaments between the scaphoid, lunate and triquetrum (Fig. 1). Flexion and extension of the wrist result from movements between the radius and the lunate, between the lunate and the capitate in the centre of the wrist, between the trapezium, trapezoid and scaphoid on the lateral side, and between the triquetrum and the hamate on the medial side (Fig. 2). There is no differential motion between the medial and lateral sides of the wrist and approximately half the range of flexion/extension occurs at the radiocarpal joint and half at the midcarpal joint.

In radial deviation the distance between the trapezium and the radial styloid shortens and in ulnar deviation it lengthens (Fig. 3). Two principal movements allow this to occur. First, there is sliding of the scaphoid into the lunate fossa during radial deviation and sliding of the lunate into the scaphoid fossa during ulnar deviation. Secondly, there is a movement which can be described as simple flexing of the scaphoid under the compression of the trapezium during radial deviation, and passive extension during ulnar deviation. The triquetrum passively follows the other two bones of the proximal row. Most wrists show both types of motion, but in varying proportions. Wrist which mainly slide are called 'row' types and those in which flexion predominates are called 'column' types. The triquetrum articulates with the hamate at a helical joint which allows sliding and flexing to occur. Flexion of the scaphoid, however, is greater than that of the triquetrum and the lunate becomes therefore an intercalated torque converter between scaphoid and triquetrum during radial and ulnar deviation. The lunate is also an intercalated segment between the radius and the capitare.

Taleisnik’s (1985) modification of Navarro’s concept of longitudinal columns (Fig. 4) has made the collapse deformities of the wrist much easier to understand. When the ligamentous supports of the scaphoid are ruptured,
The extrinsic ligaments of the carpus (a) palmar (b) dorsal. 1) radioscapohocapitate ligament, 2) radiolunate ligament, 3) ulnar triquetrocapitate ligament, 4) space of Poirier, 5) radiotriquetral ligament, 6) scaphotriquetral ligament.

Fig. 1a
Fig. 1b

The normal wrist in flexion and extension.

Fig. 2

The normal wrist in radial and ulnar deviation.

Fig. 3
The lunate, capitate, hamate, trapezoid and trapezium; triquetrum; and (b) two rows: scaphoid, lunate and triquetrum; hamate, capitate, trapezoid and trapezium.

The normal kinematics of radial/ulnar deviation and flexion/extension were investigated in detail by Youm et al (1978). They found that rotation occurred around a fixed axis in the middle of the head of the capitate and that this was independent of the position of the hand. The distance from the base of the third metacarpal to the distal articular surface of the radius (the carpal height), measured along the axis of the third metacarpal, was constant throughout radial and ulnar deviation; the perpendicular distance of the fixed axis of rotation from the distally projected longitudinal axis of the ulna was also constant.

These measures can be used to quantify respectively carpal collapse and carpal translocation. Ruby et al (1988) used a similar but more sophisticated technique to show that the wrist functions as two carpal rows, the proximal row acting as an intercalated segment of variable geometry which was confirmed by Sennwald et al (1993). Movement of the intercarpal joints in the proximal row accounted for 40% of flexion, 33% of extension and 10% of ulnar deviation (Seradge et al 1990).

The intercarpal ligaments have been studied by several authors. The scapholunate ligament was first investigated by Logan et al (1986) who described its dorsal and volar components. Hixson and Stewart (1990) examined the radioscapholunate ligament and found that it had an abundant blood supply. Berger, Kauer and Landsmeer (1991) thought that the structure should not be considered a ligament, but this was disputed by Taleisnik (1985). The dorsal capsular ligaments were

longitudinal compression forces the scaphoid into a flexed position. The lunate, being narrower anteriorly than dorsally, tends to extend under compression. Coincident extension of the lunate with flexion of the scaphoid can occur only if the ligamentous connections between them are damaged. Both bones collapse into their ‘default’ positions only when there is severe ligament injury on the radial side of the carpus and this pattern is termed dorsal intercalated segment instability (DISI) (Fig. 5). The classical mechanism of this injury is a fall on the outstretched, extended wrist. If the thenar eminence strikes the ground first, there is an additional supination element to the extension and compression forces.

If the hypothenar eminence strikes the ground first the resulting pronation disrupts the dorsal ulnar-triquetal ligament complex, the triquetrolunate interosseous ligament and the anterior midcarpal capsule. This allows the capitate to hyperextend in relation to the lunate, which compensates by flexing (Fig. 6). Subluxation of the midcarpal joint is seen at rest on lateral radiographs and this pattern is termed volar intercalated segment instability (VISI).
studied by Mizuseki and Ikuta (1989) who found that neither the dorsal radioulnar ligament nor the ulnar collateral ligament could be isolated as discrete condensations.

Viegas et al (1989) considered how loads were transmitted across the wrist. They found that the scaphoid fossa constituted 60% of the total contact area and the lunate fossa 40%. At the midcarpal joint load was distributed as follows: 23% at the scaphotrapeziotrapezoid joint, 28% at the scaphocapitate joint, 29% at the lunocapitate joint and 20% at the triquetrohamate joint (Viegas et al 1993).

Although the injury which causes carpal instability is almost always hyperextension, the precise pathomechanics are little understood. A study of cadaver wrists by Mayfield (1984) identified four stages of lunate instability:
1) Instability limited to the scapholunate joint.
2) Added instability of the capitulunate joint.
3) Added damage to the triquetrolunate joint.
4) Dorsal disruption of the radiocarpal ligament leaving the lunate totally unstable.

The displacements required to produce this type of injury were extension, ulnar deviation and intercarpal supination.

Other research on specific instabilities has sought to identify those structures which need to be damaged to produce the observed radiological appearances. Trumble et al (1990) found that the pattern of VISI required rupture of the triquetrohamate and triquetrolunate ligaments. Hori et al (1991) concluded that the essential lesion to produce such an instability pattern was rupture of the dorsal radiotriquetral and dorsal scaphotriquetral ligaments plus damage to the lunotriquetral ligament and interosseous membranes.

The long-term effects of instability on the wrist were evaluated by Blevens et al (1989) who used pressure-sensitive film to record changes in the radioscapoid and radiolunate contact areas after sequential ligament section. They found that the scapholunate interosseous ligament was essential for preventing scapholunate diastasis and that the change in contact area after its division would explain the later development of degenerative arthritis. Benninghaus, Koob and Steffens (1992) showed that carpal instability does indeed lead to degenerative arthritis.

CLASSIFICATIONS

The International Wrist Investigators Workshop Nomenclature Committee was set up to define the terms used to describe carpal instability but as yet no one system has been agreed on. The most frequently used terms are those introduced by Linscheid et al (1972) and Dobyns et al (1975) who identified four groups of carpal instability: dorsal flexion instability (DISI); volar flexion instability (VISI); ulnar translocation; and dorsal subluxation.

The radiological appearances of the dorsal flexion and volar flexion instability patterns have already been discussed. Ulnar translocation describes ulnar shift of the carpus on the radius and is commonly seen in patients with rheumatoid arthritis. Dorsal subluxation describes dorsal shift of the carpus, often seen after malunion of distal radial fractures (Dias and McFarland 1988).

Taleisnik (1985) introduced the concepts of static and dynamic instability. Static instability is an end state, with marked scapholunate dissociation, fixed flexion of the scaphoid and fixed extension of the lunate. Dynamic instability exists when partial ligament injuries cause pain but with minimal or even no changes on the static radiograph, the diagnosis being made by dynamic
radiology or arthroscopy. The terms carpal instability dissociative (CID), carpal instability non-dissociative (CIND) and carpal instability complex (CIC) were introduced by Dobyns in 1990. CID describes instability due to loss of linkage between the individual bones of either row; CIND means that there is no dissociation between individual carpal bones but instability at the radiocarpal or midcarpal joints; and CIC includes instabilities which were not otherwise classifiable.

**DIAGNOSIS**

**Clinical tests.** Of paramount importance in the diagnosis of carpal instability are a careful history and physical examination. Attention must be paid to the position of the wrist at the time of injury and the location of pain. Swelling and local tenderness are noted and the ranges of motion and grip strengths of the injured and uninjured sides are measured. The most important differential diagnosis for pain on the radial side of the wrist is a fracture of the scaphoid. The problems of early diagnosis of this injury are well known, but after two to three weeks the standard tests for carpal instability can be performed. The pseudoinstability test, described by Kelly and Stanley in 1990, in which there is loss of the normal forward glide of the carpus (Fig. 7) is useful. Lack of this motion due to protective spasm is akin to the positive apprehension sign of shoulder instability. Other tests include that of Watson, Ryu and Akelman (1986) which stresses the scapholunate intersosseous ligament (Fig. 8). Scapholunate or lunotriquetral ballotment may reveal specific joint instability and Lichtman et al (1981) described a pivot shift test for midcarpal instability. All of these are specific for a particular ligamentous lesion but overlap is not uncommon and perhaps the most specific and reliable test is point tenderness over the affected ligament.

**Imaging.** The work of Schernberg (1990) on the radiological examination of the normal wrist has shown the importance of the quality and reproducibility of the films. On the posterior/anterior view, the width of the scapholunate gap should be no greater than that of the triquetrolunate gap, and Gilula and Weeks (1978) found that a scapholunate angle greater than 80° was indicative of DISI. Schernberg (1990) found that stress views were needed to diagnose 18 out of 27 cases of wrist injury. Degreif et al (1990) advocated comparison of both wrists because of the considerable variations in normal anatomy. Larsen et al (1991) reported great interobserver variation in radiographic measurements and recommended the use of well-defined axes. Other authors (Lichtman et al 1981; Stanley 1993) have found that examinations under an image intensifier are useful for dynamic instabilities.

Special investigations including narrow-bore collimator scintigraphy, ultrasound, MRI and CT may be useful and three-phase arthograms and three-dimensional reconstruction of CTR arthrography can be used to

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**Fig. 7**

Pseudostability test for carpal instability undertaken with the examiner holding the carpus firmly with one hand and the distal forearm with the other and performing anteroposterior translation. Often in carpal instability this translation is reduced.
demonstrate leakage of contrast between the various intercarpal joints. Herbert et al (1990) showed, however, that an arthrogram is of little diagnostic value unless it can be compared with that of the opposite undamaged wrist.

As mentioned above, scintigraphy has been used to diagnose Preiser’s disease, Kienbock’s disease and avascular necrosis of the capitate but bone scans are not useful in the diagnosis of carpal instability. CT has now replaced other forms of tomography in the assessment of complex injuries of the carpus (Stewart and Gilula 1992).

MRI appears to have the greatest potential (Zlatkin and Greenan 1992) but, like CT, it gives only static images. Even the use of surface coils, improved software and the addition of gadolinium contrast have failed to improve its diagnostic accuracy and the method often fails to reveal minor tears of the triquetrolunate interosseous ligament (Munk et al 1992).

**Arthroscopy.** Arthroscopy of the radiocarpal and midcarpal joints is the best method for the diagnosis of carpal instability. Roth and Haddad (1986), Kelly and Stanley (1990) and Cooney (1993) have all advocated its use and there is no doubt that it can provide much information about the altered mechanics and pathology of the wrist at all levels. Kelly and Stanley (1990) and Dautel, Goudot and Merle (1993) examined groups of patients with symptoms suggestive of scapholunate interosseous ligament tear but with normal radiographs and established the diagnosis by dynamic manoeuvres undertaken during radiocarpal and midcarpal arthroscopy (Fig. 9). Fischer and Sennwald (1993) detected ligament tears by arthroscopy in every wrist in 20 cases of carpal instability.

**TREATMENT**

**Scapholunate dissociation.** When this condition is diagnosed early and treatment is indicated, an attempt should be made to bring about healing of the torn interosseous ligament. Palmer, Dobyns and Linscheid (1978) reported good results from immobilisation for eight weeks in plaster if treatment started within four weeks of injury and if an anatomical reduction was
maintained. This often required the use of closed pinning
with a Kirschner wire under radiographic control. Cases
that cannot be reduced and held by this technique, and
those diagnosed later, do poorly with immobilisation, and
often require surgery. Ligament reconstruction, whether
undertaken through a volar or a dorsal approach (Taleisnik
1985), often needs supplementary Kirschner-wire fixation
and the results range from good to fair depending on the
quality of the tissue available for repair.

If the diagnosis is delayed for three months or more
it becomes even more difficult to repair what is left of the
interosseous ligament. If the disability is minor, with
more than 80% of the range of motion and grip strength
retained, no treatment is required (Dobyns et al 1975),
but if there is a significant disability, a number of surgical
procedures are available. Dobyns et al (1975) advocated
splitting one of the radial wrist extensor tendons and
passing half of it as a loop through the scaphoid and
lunate; Taleisnik (1985) advocated the use of a free tendon
graft in the same way. Glickel and Millender (1984)
reviewed 21 cases so treated and found that range of
motion and grip strength had improved slightly but that
the radiographs showed loss of much of the early
correction. Almquist et al (1991) used a four-bone-
ligament reconstruction and also reported clinical im-
provement and radiological recurrence of the deformity;
most of the patients returned to their preinjury activities
including heavy labour. Conyers (1990), who performed
imbrication of the palmar ligaments and chondrodesis
between the scaphoid and lunate, reported improvement
of the pinch and grip strengths and the range of motion.

Lavernia, Cohen and Taleisnik (1992) advocated direct
scapholunate ligament repair and dorsal radioscaphoid
capsulodesis for most scapholunate dissociations in which
there was no osteoarthritis present, regardless of the
time lapse since injury. Blatt and Nathan (1992) described
dorsal capsulodesis for rotatory subluxation of the
scaphoid. In this procedure palmar flexion of the scaphoid
is prevented by a dorsal capsular check-rein; a long-term
review of 30 patients showed satisfactory clinical results
and MRI suggested physiological hypertrophy of the
transferred tissue.

The indifferent results of ligament reconstruction
have persuaded many surgeons to perform an intercarpal
arthrodesis, the most logical of which is scapholunate
arthrodesis. Hom and Ruby (1991) reported, however,
that of seven patients only one showed radiographic
fusion and three still had significant symptoms; Alnot, De
Cheveigne and Bleton (1992) had similar problems. In
view of these difficulties, attention turned to the scaphoid-
trapezoid-trapezium (STT) joint. Watson and Hempton
(1980) found that STT fusion was readily obtained and
was successful in rotatory subluxation of the scaphoid,
preserving 80% of the range of flexion/extension and 66% of
the range of radial and ulnar deviation. These findings
were supported by Kleinman, Steichen and Strickland
(1982), nine of their 12 patients returning to preinjury
activities without wrist pain and with 80% of the
preoperative range of motion. More recently, however,
Eckenrode, Louis and Greene (1986) reported less good
results. Voche et al (1991) found that patients maintained
60% of their preoperative range of motion but that the
radiographs revealed styloid impingement in 34% of
cases. Fortin and Louis (1993) showed that 8 out of 14
patients had significant residual symptoms and 11 had
complications including radiocarpal and trapeziometacar-
al arthritis and nonunion.

Scaphocapitate arthrodesis is easier to undertake.
Pisano et al (1991) found that although it reduced wrist
movement, particularly radial deviation, grip strength was
good and only two patients out of 17 required reoperation
for nonunion. Our own experience, and that of Kleinman
(1990) of this procedure, is that a few patients develop
osteoarthrosis due to the excessive force between the
scaphoid and the dorsal half of the scaphoid fossa.

Lunotriquetral dissociation. This is a less common
problem than scapholunate dissociation but it occasionally
requires surgical treatment. Reagan, Linscheid and
Dobyns (1984) found that simple immobilisation was
useful only for acute injuries; capsulodesis, tenodesis and
arthrodesis have been used for chronic cases. Pin et al
(1989) had no failure of fusion in 11 cases, but three
patients had persistent pain. Most of the range of motion
was preserved but only 59% of grip strength. Kirschen-
baum, Coyle and Leddy (1993) also advocated fusion but
Nelson et al (1992) reported problems of nonunion and
recommended using a Herbert screw as well as a Kirschner
wire for fixation, plus a cast for at least eight weeks.

We recommend triquetrohamate fusion as being
easier to achieve. If, however, on arthroscopy a posterior
triangular fibrocartilaginous complex tear is found but no
midcarpal instability, then a reconstruction of the ulnar
dorsal capsule using half the tendon of extensor carpi
ulnaris is preferred. For combined midcarpal and trique-
etrohamate instability the so-called ‘four-corner’ or luno-
triquetropatohamate fusion is indicated.

Midcarpal instability. Lichtman et al (1981) described
this instability and investigated its pathomechanics. They
also described a diagnostic test, which causes a painful
click on ulnar deviation, compression and pronation of
the wrist. The radiographs are usually normal but cinefluoroscopy can show dissociation between the
proximal and distal carpal rows with volar collapse
deformity. Laboratory studies have shown volar subluxa-
tion of the capitate and hamate on the lunate and triquetrum. Johnson and Carrera (1986) identified atten-
uation of the radiocapitate ligament as the cause of this
condition and advocated tightening the ligament to
obliterate the space of Poirier, but soft-tissue reconstruc-
tions have usually failed and midcarpal arthrodesis is
preferred (Lichtman et al 1993).

Carpal instability resulting from malunion of a
fracture of the distal radius in dorsal angulation can be
effectively treated by distal radial osteotomy (Sennwald,
Fischer and Stahelin (1992) but if the carpal ligaments have been damaged it is rarely successful.

Post-traumatic ulnar translation of the carpus has not been successfully treated by soft-tissue repair (Chamay, Della Santa and Vielasca; 1983; Rayhack et al, 1987) and most authors now advocate radiolunate fusion for this problem.

**Secondary osteoarthritis.** The loss of motion and altered biomechanics which result from intercarpal arthrodesis may give rise to osteoarthritis in the long term. The particular contribution of each intercarpal joint to total wrist motion was measured by Gellman et al (1988). Palmer et al (1985) measured functional wrist motion and found that the normal range was 5° of flexion, 30° of extension, 10° of radial deviation and 15° of ulnar deviation, values which lie well within the range of most wrists after intercarpal arthrodesis. Scaphotrapeziotrapezoideal fusion and scaphocapitate fusion have been found to produce a similar reduction in range of motion. Both procedures increased the sliding motion of the lunate on the radius (Garcia-Elias et al 1989) and Viegas et al (1990) found that afterwards virtually all the load was transmitted to the scaphoid fossa. Other fusions, scapholunate, scapholunocapitate and capitulolunate, all distributed the load more equally through both the scaphoid and lunate fossae. The position of the scaphoid in scaphotrapeziotrapezoideal fusions is important; if it is vertical there is a greater loss of flexion and ulnar deviation; if it is horizontal, extension and radial deviation are lost. If the scaphoid is in anatomical alignment scaphotrapeziotrapezoideal and scaphocapitate fusion result in similar patterns of motion (Ambrose et al, 1992).

The treatment of carpal instability when there are already arthritic changes in the wrist was described by Watson and Ballet (1984). They defined scapholunate advanced collapse (SLAC), a sequential pattern of arthritis affecting first the radial fossa and then the capitulolunate joint but sparing the radiolunate joint (Fig. 10). They recommend reduction of the so-called DISI, excision of the scaphoid and fusion of the capitate, hamate, lunate and triquetrum. Of the 19 patients treated, 18 had some pain relief while maintaining an adequate range of motion. Krakauer, Bishop and Cooney (1992) operated on 55 patients with SLAC and obtained the best results with scaphoid excision and a ‘four-corner fusion’. Saffar and Fakhoury (1992) compared proximal row carpectomy with partial wrist arthrodesis and found that the latter gave better results.

**Conclusions.** Carpal instability may result from a variety of wrist injuries and is important in the differential diagnosis of chronic wrist pain. Over the last decade, much has been added to our knowledge about these injuries but more remains to be understood. Diagnosis and treatment are often difficult and require special skills. At this time the authors’ preferred method of investigation includes a thorough clinical and radiological examination including stress views. Most patients then undergo arthroscopy to confirm the provisional diagnosis and to exclude other pathology. Treatment depends on the patients’ symptoms. For those with little disability and more than 80% of the range of motion and grip strength, surgical treatment is not indicated.

For those with more serious problems from acute scapholunate dissociation (within six weeks of injury), direct repair and dorsal capsulodesis are recommended; for cases seen later a full Blatt dorsal capsulodesis is required. If, however, reduction of the dorsal intercalated segment cannot be maintained, scaphocapitate fusion is preferred. For an isolated lunotriquetral disorder arthrodesis of this joint only is performed; for midcarpal instability a triquetrohamate arthrodesis is preferred. Finally, for patients with secondary arthritis either a ‘four-corner fusion’ with scaphoid excision or a total wrist arthrodesis is advised depending upon the extent of the arthritis and the patients’ individual requirements.

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**REFERENCES**


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