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TWENTY QUESTIONS ON CARPAL INSTABILITY

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THE QUESTIONS

1. What is carpal instability?
2. How common is it?
3. How does it occur?
4. Is carpal instability always associated with a traumatic event?
5. Does ligament laxity play a part?
6. What is unstable?
7. How does this affect the normal bio-mechanics of the wrist?
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16. What soft tissue procedures are available for treating chronic carpal instability?
17. What bony procedures are available for treating chronic carpal instability?
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1. WHAT IS CARPAL INSTABILITY?

Instability is defined in the Oxford English Dictionary as ‘a lack of stability’. The latter being defined as ‘abiding, fair, steady, constant’.

In the Western World, injuries to the carpal ligaments resulting in malalignment were, probably, first recognised by Destot (1926) and, somewhat later, by Gilford et al. (1943). The latter were the first to describe the wrist as a link joint which was stable under tension because of the position and size of the scaphoid. Fisk (1970) described carpal instability arising from non-union of the scaphoid as a zig-zag, or concertina deformity. Linscheid et al. (1972) proposed a classification and offered a definition of a carpal injury in which a loss of normal alignment of the carpus develops early or late. More recently, the Anatomy and Biomechanics Committee of the International Federation of Societies for Surgery of the Hand concluded that ‘a wrist joint should be considered clinically unstable only if it exhibits a symptomatic dysfunction, is not able to bear loads and does not exhibit normal kinematics during any portion of its arc of motion’.

2. HOW COMMON IS IT?

In 1975, Dobyns et al. reviewed their own experience and that of the Bohler Clinic and reported that 10% of all carpal injuries resulted in instability. Jones (1988) studied a consecutive series of 100 patients who had suffered 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 definitive scaphoid–lunate instability. Kelly and Stanley (1990) reviewed 98 consecutive wrist arthroscopies and identified numerous ligamentous injuries, findings that were confirmed by Sennwald et al. (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% of the wrists.

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 just over 30%. However, Nakamura et al. (1991), having performed an arthroscopy on the wrists of a group of patients with ununited scaphoid fractures, found that most did not have any serious ligamentous injuries.

In rheumatoid arthritis, the incidence of the radiological signs of carpal instability appears to be much commoner, particularly in the early stages. Kushner and Dawson (1992) and Kushner et al. (1993) from Rochester, New York, analysed X-ray patterns in 52 patients with proven rheumatoid arthritis. Of these, 19 patients exhibited one, or more, patterns of instability. The most common isolated pattern was volar intercalated segmental instability (VISI), seen in six patients. Five patients showed more than one pattern, most commonly a combination of ulnar translocation and volar carpal subluxation. They concluded that carpal instability is a frequent mechanical consequence of rheumatoid arthritis.

3. HOW DOES IT HAPPEN?

There is much debate as to the exact mechanism of injury that produces the various types of carpal instability. However, most researchers and experts accept that this injury is usually the result of a fall on the outstretched hand with the wrist in hyperextension.
A study on cadaveric wrists by Mayfield (1984) identified four stages of lunate instability. These were:

1. Instability limited to the scapholunate joint.
2. Added instability of the capitolunate joint.
3. Added damage to the triquetrolunate joint.
4. Dorsal disruption of the radiocarpal ligament leaving the lunate completely unstable.

Using a cadaveric model, the forces to reproduce these types of injury were mimicked by having the wrist in extension, ulnar deviation and intercarpal supination. This supination occurs as a result of the thenar eminence striking the ground first. If, however, the hypothenar eminence strikes first, then the resulting pronation disrupts, predominantly, the dorsal ulna-triquetral complex, the triquetrolunate intersosseous ligament and the anterior carpal capsule. The result of this is that the instability is predominantly on the ulnar side of the wrist.

4. IS CARPAL INSTABILITY ALWAYS ASSOCIATED WITH A TRAUMATIC EVENT?

Most researchers and clinicians accept that, in the overwhelming majority of cases, carpal instability will follow a single traumatic event as described above. It should also be noted that intercarpal ligament damage can also occur in association with both scaphoid (Wong et al., 2005) and distal radial fractures (Laualan and Bismuth, 1999). At this time, there is little published evidence to suggest that these conditions can follow repeated, or repetitive, lesser traumas. Schroer et al. (1996) looked at the prevalence of carpal instability in a paraplegic population. Of 162 paraplegic patients, 9 had a static carpal instability and none of these patients had a history of acute injury to the wrist. The predominant pattern of instability in 11 of the wrists, in 6 patients, was non-dissociative volar intercalated segmental instability. They also noted that the prevalence of carpal instability increased with the duration of weight bearing on the upper extremity. Eighteen per cent of the patients in whom the spinal cord injury had occurred more than 20 years before the study had carpal instability. They concluded that this increased incidence of carpal instability in weight bearing upper extremities, particularly the increase in prevalence with the duration of the forces transmitted across the wrist, demonstrated an association between chronic repetitive stress on the wrist and carpal instability.

Finally, the presence of a static dorsal intercalated segmented instability (DISI) can often be seen in patients suffering with scapho-trapezio-trapezoid (STT) osteo arthritis. Ferris et al. (1994) found this combination in 16 of 63 wrists of patients with this condition.

5. DOES LIGAMENT LAXITY PLAY A PART?

Undoubtedly, the answer to this question is yes. Patients with joint-laxity often have excessive mobility in the wrist joint, with X-ray appearances of a hyperflexed scaphoid and lunate. Garcia-Elias et al. (1995) analysed the kinematic behaviour of the scaphoid during radio-ulnar deviation of the wrist in 60 normal volunteers. They also assessed wrist laxity using criteria set out by Larsen et al. (1987). They concluded that there was a linear relationship between scaphoid rotation and the amount of wrist joint laxity. More specifically, during lateral deviation of the wrist, joints that were more lax had a scaphoid rotating mainly along the sagittal plane of flexion-extension, with little lateral deviation. Whereas, in the volunteers with decreased laxity, the scaphoids mostly rotated along the frontal plane, with minimal flexion-extension. Fortunately, most patients were asymptomatic. There is no doubt, however, on occasion and often after relatively minor trauma, the wrist can become symptomatic. This often presents as a painful clunking which the patient is readily able to demonstrate. Examination under image-intensifier demonstrates obvious instability at the mid carpal joint, particularly between the capitate and lunate, with the head of the capitate subluxing out of the distal, convex articular surface of the lunate.

6. WHAT IS UNSTABLE?

To understand what structures are damaged following trauma, it is important to have a thorough knowledge of the normal anatomy of the wrist and carpus.

The ligaments of the wrist are divided into intrinsic and extrinsic components. The two most important intrinsic (intersosseous) ligaments, viz. the scapholunate and lunotriquetral ligaments, are divided into dorsal, proximal and palmar parts. The thickest and strongest part of the scapholunate ligament is located dorsally (Berger et al., 1999) (Fig 1) and that of the lunotriquetral ligament is located palmarly.

With regard to the extrinsic ligaments, there are several described on both the palmar and dorsal aspects of the wrist. It is generally accepted that those on the palmar aspect provide greater restraint to instability (Katz et al., 2003). There are three strong palmar extrinsic radiocarpal ligaments, viz. the radioscaphocapitate, the long radiolunate and the short radiolunate ligaments (Fig 2). The radioscaphocapitate ligament, which extends from the radial styloid process through a groove on the waist of the scaphoid to the palmar aspect of the capitate, acts as a fulcrum around which the scaphoid rotates. The long radiolunate ligament, which lies parallel to the radioscaphocapitate ligament, extends from the palmar rim of the distal part of the radius to the radial margin of the palmar surface of the lunate. Located between the radioscapophocapitate and long...
radiolunate ligaments, at the level of the midcarpal joint, is an area of capsular weakness known as the space of Poirier. The short radiolunate ligament, which is contiguous with the palmar fibres of the triangular fibrocartilage complex, originates from the palmar margin of the distal part of the radius and inserts into the proximal part of the palmar surface of the lunate. The ulnolunate and ulnotriquetral ligaments arise from the volar edge of the triangular fibrocartilage and insert into the lunate and the triquetrum, respectively.

With regard to the radio-scapholunate ligament, Berger et al. (1991) felt that this structure could not be considered a true ligament, although this was disputed by Taleisnik (1984).

Most authors agree that when the wrist and the carpus are injured, both the intrinsic and extrinsic ligaments are damaged. Generally, however, it is felt that for significant carpal instability to exist, the interosseous ligaments, specifically the scapholunate and lunotriquetral, have to be permanently damaged. On the ulnar side, Trumble et al. (1988) found that the pattern of volar intercalated segmental instability (VISI) required the rupture of both the triquetrohamate and triquetrolunate ligaments.

Returning to the radial side of the wrist, a number of authors believe that the principal area of ligament damage lies distally between the scaphoid and trapezium. Work by Short et al. (2005), however, confirmed that the scapholunate interosseous ligament is the primary stabiliser of the wrist and that the radio-scaphocapitate and scapho-trapezial ligaments act only in a secondary capacity.

Finally, we should also remember that the constitution of these ligaments changes with age. Weiss et al. (1994), in a cadaveric study, were able to identify scapholunate and lunar triquetal ligament defects in approximately 30% of cases. It should be noted, however, that most of these were in the central, or weakest, part of the ligament and did not represent true tears, lesions or defects. In addition, over half of the cadavers also had triangular fibro-cartilage tears.

7. HOW DOES THIS AFFECT THE BIOMECHANICS OF THE WRIST?

Whilst our knowledge of the biomechanics of the wrist remains incomplete, it is not possible to understand the effect of these ligament injuries and instability patterns without having some knowledge of what is believed to be normal. The distal row of bones, viz. the trapezium, trapezoid, capitate and hamate, form a stable platform upon which the metacarpals are fixed. There is very little motion between these bones. Similarly, the distal radius and ulna, although they move in pronation and supination, are essentially a stable construct. The proximal row of the carpus, however, is an intercalated segment with no muscle or tendon insertions, the stability of which depends entirely on the capsular and interosseous ligaments between the scaphoid, lunate and triquetrum. Flexion and extension of the wrist results from movement between the radius and the lunate and 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. Further research has shown that movement of the intercarpal...
joints of the proximal row (radiocarpal) accounts for 40% of flexion, 33% of extension and 10% of ulnar deviation (Seradge et al., 1990).

In radial deviation, the distance between the trapezium and the radial styloid shortens. This distance lengthens in ulnar deviation (Figs 3 and 4). Two principal movements allow this to occur. Firstly, there is sliding of the scaphoid over the lunate fossa during radial deviation and sliding of the lunate over the scaphoid fossa during ulnar deviation. Secondly, there is a movement which can be described as simple flexing of the scaphoid under the trapezium during radial deviation and 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 (Nuttall et al., 1998). Wrists 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 at the scaphoid, however, is greater than that of the triquetrum and the lunate, therefore, becomes an intercalated torque converter between the scaphoid and triquetrum during radial and ulnar deviation. The lunate is also an intercalated segment between the radius and the capitate.

Taleisnik’s (1984) modification of Navario’s concept of longitudinal columns (Fig 5) has made the collapse deformities of the wrist much easier to understand. When the ligamentous supports of the scaphoid are ruptured, longitudinal compression forces the scaphoid into a flexed position. The lunate, being narrower anteriorly than dorsally, tends, normally, to extend under compression. Coincident extension of the lunate with flexion of the scaphoid can occur only when there is severe ligament injury on the radial side of the carpus and this pattern is termed “dorsal intercalated segment instability” (DISI).

If, however, the damage affects the dorsal ulno-triquetral ligament complex, the triquetrolunate inter-osseous ligament and the anterior midcarpal capsule, this allows the capitate to hyperextend in relation to the lunate, which compensates by flexing. Subluxation of the midcarpal joint is seen at rest on lateral radiographs and this pattern is termed “volar intercalated segment instability” (VISI).

The normal kinematics of radial/ulnar deviation and flexion/extension were further 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 (Fig 6). These measures can be used to quantify carpal collapse and carpal translocation, respectively.

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

8. HOW DO WE DIAGNOSE IT CLINICALLY?

Of paramount importance for 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 and compared. 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 a loss of the normal anteroposterior translation 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 et al. (1986), which stresses the scapholunate interosseous ligament (Fig 8).

![Fig 6 Carpal height.](image_url)

Carpal height ratio = L1/L2 = 0.54 ± 0.03

![Fig 7 Pseudoinstability test.](image_url)

![Fig 8 Watson’s manoeuvre.](image_url)
causes scaphoid flexion, which is able to overcome the resistance of an examining thumb on the scaphoid tubercle. In a scapholunate dissociation with radial deviation, the scaphoid flexes, but is unable to overcome the volar resistance of the thumb. The scaphoid has to escape and is forced dorsally, with the proximal pole clunking dorsally. Scapholunate or lunotriquetral ballotment may reveal specific joint instability and Lichtman et al. (1981) described a pivot shift test for midcarpal instability (Fig 9). All of these tests are specific for a particular ligamentous lesion, but overlap is not uncommon. Perhaps, the most specific and reliable test is point tenderness over the affected ligament.

9. WHAT ARE THE VALUE OF X-RAYS INCLUDING ARTHROGRAPHY?

The work of Schernberg (1990) on the radiological examination of the normal wrist has shown the importance of the quality and reproducibility of the images obtained. On the posterior/anterior views, the width of the scapholunate gap should be no greater than that of the triquetrolunate gap, which is no more than 3 mm (Fig 10). Gilula and Weeks (1978) found that a scapholunate angle greater than 80° was indicative of DISI (Fig 11). Schernberg also found that stress views were needed to diagnose 18 out of 27 cases of wrist injury. In addition, Degreif et al. (1990) advocated comparison of both wrists because of the considerable variations in normal anatomy. Other authors (Lichtman et al., 1981) have found that examination under an image intensifier can be particularly useful for dynamic instabilities.

More sophisticated investigations, including arthrography and scintigraphy, may be of value. Arthrography can, undoubtedly, demonstrate leakage of contrast between the various intercarpal joints. Herbert et al. (1990), however, showed that an arthrogram is of little diagnostic value unless it can be compared with that of the opposite, undamaged wrist.

Scintigraphy has been used to diagnose Preiser’s and Kienböck’s diseases and avascular necrosis of the capitae, as well as to exclude various bone tumours. Generally, however, this investigation is considered not to be particularly useful in the diagnosis of longstanding carpal instability.

10. WHAT IS THE VALUE OF MRI/CT SCAN

CT and MRI scans are increasingly being used in the investigation of chronic wrist pain. Certainly, the CT scan has replaced other forms of tomography for the investigation of complex injuries of the carpus (Stewart and Gilula, 1992). MRI, however, appears to have the greatest potential (Zlatkin and Greenan, 1992) although, like CT, it only gives static images. Initially, MRI scans often failed to reveal small tears of the interosseous ligaments (Munk et al., 1992). Work by Schädel-Höpfner et al. (2001) from Germany revealed that the addition of intravenous contrast did not improve the accuracy of MRI scanning significantly. Certainly, it did not compare with wrist arthroscopy. At our hospital, however, with the additional use of surface coils and improved software, we believe that the diagnostic value of MRI arthrograms have improved considerably.
11. DOES ARTHROSCOPY HAVE A PLACE?

Arthroscopy of the radiocarpal and midcarpal joints remains the gold standard in 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 et al. (1993) examined groups of patients with symptoms suggestive of a scapholunate interosseous ligament tear, but with normal radiographs and established the diagnosis by dynamic manoeuvres undertaken during radiocarpal and midcarpal arthroscopy. Fischer and Sennwald (1993) detected ligament tears by arthroscopy in every wrist, in 20 cases of carpal instability. Other, and more recent, reports have indicated that arthroscopic evaluation of the wrist is more accurate and specific than arthrography in detecting the site and extent of ligament injury (Cooney et al., 1990; Weiss and Akelman, 1995).

At the radiocarpal level, the volar carpal ligaments are assessed in a radial to ulnar direction to determine whether an extrinsic ligament injury has occurred. Midcarpal arthroscopy with the use of a triangulation probe is also performed routinely. The space between the scaphoid and lunate bones is assessed for evidence of ligamentous laxity. A diagnosis of partial, or complete, carpal ligament injury is established on the basis of the ease of separation of the scaphoid from the lunate (Fig 12) and of the lunate from the triquetrum. This is facilitated by unloading the wrist and stressing the various joints. Geissler, initially, classified the arthroscopic findings of a scapholunate ligament injury. These were, if the probe can be rotated within the space, a tear of the scapholunate or lunotriquetral interosseous ligament is probable. If either the probe, or the arthroscope, can be passed from the midcarpal to the radiocarpal joint, rotatory subluxation of the scaphoid (a complete scapholunate ligament tear with extrinsic ligament laxity) is confirmed. This has been further classified by Kozin (1999) (Table 1). Returning to the radiocarpal joint, a triangulation probe assists in the assessment of the size, location and extent of tears of the triangular fibrocartilage complex. Associated osseous injuries (fractures of the proximal pole of the scaphoid or dorsal triquetral chip fractures) can be visualised also.

12. WHAT ARE THE COMPLICATIONS OF WRIST ARTHROSCOPY?

Wrist arthroscopy is a relatively safe procedure when performed correctly. Of particular note, are potential traction injuries, including degloving of the finger skin by the finger traps. However, with the application of these traps to a minimum of three fingers, the advent of plastic, rather than metal, traps and traction of no more than 2.5 kg (5 lbs), the risk is negligible. Compartment syndrome is also a potential complication, although, again, if gravity inflow is used, it is extremely unlikely. If a fluid management system is required, then this should be used judiciously. An Esmarch bandage pre-wrapped around the forearm to prevent over distension may be useful. Finally, tourniquet palsy and infection are also possibilities.

With regard to nerve injury, damage to the dorsal sensory branch of the ulnar nerve can follow the use of the 6U portal. This results in a painful neuroma, which can persist. In addition, patients can be left with a small permanent area of anaesthesia distally. Another sensory nerve particularly at risk is the dorsal cutaneous branch of the superficial radial nerve. This is particularly at risk when the 1/2 portal is used. Finally, branches of the posterior interosseous nerve can be damaged when the 3/4, 4/5 and midcarpal portals are used. Whilst not reported, neuromas of these branches have been seen following other surgical procedures. Finally, it should be remembered that the radial nerve, or its terminal branches, may be damaged when the 1/2 portal is fashioned.

<table>
<thead>
<tr>
<th>Grade</th>
<th>Description</th>
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<tbody>
<tr>
<td>Grade 1</td>
<td>Attenuation or haemorrhage, no incongruency</td>
</tr>
<tr>
<td>Grade 2</td>
<td>Incongruency or step-off of carpal space, slight gap less than width of probe</td>
</tr>
<tr>
<td>Grade 3</td>
<td>Incongruency or step-off of carpal space, probe passed between scaphoid and lunate</td>
</tr>
<tr>
<td>Grade 4</td>
<td>Incongruency or step-off of carpal space, scope (2.7 mm) passed through gap between scaphoid and lunate</td>
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Fig 12 Scapholunate gapping as seen on midcarpal arthroscopy.
There is also a potential for damage to the extensor tendons with all the dorsal portals. Surprisingly, few cases have been reported, although the authors are aware of two in which the extensor pollicis longus tendon was transected while a 3/4 portal was being formed (Fortems et al., 1995). The injuries only became obvious after surgery and both patients required tendon repair.

13. HOW DO WE CLASSIFY CARPAL INSTABILITY?

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, viz. dorsal intercalated segment instability (DISI), volar intercalated segment instability (VISI), ulnar translocation and dorsal subluxation.

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

Taleisnik, in 1984, 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 in the presence of partial ligament injuries resulting in pain, but with minimal, or even no, changes on the plain radiographs. The diagnosis is 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 and Gabel (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. CIC includes instabilities which were not otherwise classifiable.

14. IS TREATMENT NECESSARY?

If the disability is minor, with more than 80% of the normal range of motion and grip strength retained, no treatment is required (Dobyns et al., 1975). Certainly, in our practice, a number of patients choose not to undergo reconstructive surgery and, with some modifications of life style, seem to cope extremely well with a chronic scapholunate ligament injury.

A study from Wrightington Hospital (O’Meeghan et al., 2003) summarised the outcome of 11 patients with arthroscopically proven interosseous scapholunate liga-

15. WHAT TREATMENT IS AVAILABLE IN THE FIRST INSTANCE?

(a) 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 et al. (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 supplementary closed pinning with a K-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, 1984), also, often needs supplementary K-wire fixation and the results range from good to fair, depending on the quality of the tissue available for repair. At this time, it is normal practice to repair the scapholunate ligament through a dorsal approach and the triquetrolunate ligament through a palmar approach, when possible, as this addresses the stronger parts of those ligaments. The results of direct repair were reported by Wyrick et al. (1998). They had 17 patients available for follow-up for an average of 30 months. In this series, it should be noted that the scapholunate ligament repair had been augmented by a dorsal capsulodesis. At follow up, no patient was pain free, average wrist motion was 60% of normal and grip strength 70%. Radiologically, the scapholunate angle had improved from 78°, pre-operatively, to 47° at surgery. Unfortunately, at long-term follow-up, the scapholunate angle had deteriorated back to 72°. Similar changes were noted for the scapholunate interval. Overall, only 2 patients had an excellent or good result, with 6 of the 17 having good, or excellent, results on...
X-ray analysis. As a consequence, these authors advocated a cautious approach when describing the outcome of this form of surgery.

Bickert et al. (2000) from Heidelberg, Germany, reported a retrospective analysis of acute scapholunate ligament repair using Mini bone anchors. At follow-up at a mean of 19 months after surgery, results were found to be good or excellent in 8 patients, satisfactory in 2 and poor in a further 2. Assessments were by pain score, grip strength and DASH. Radiological assessment revealed stable scapholunate ligaments in 10 patients: by this, it was meant that the mean scapholunate angle was 55° with a scapholunate gap of no more than 3.2 mm.

(b) Lunotriquetral dissociation

This condition is less common and, again, if diagnosed early, can be treated by either simple immobilisation or acute ligament repair. Reagan et al. (1984) found that simple immobilisation was only useful for acute injuries, capsulodesis, tenodesis and arthrodesis being reserved for chronic cases.

16. WHAT SOFT TISSUE PROCEDURES ARE AVAILABLE FOR TREATING CHRONIC CARPAL INSTABILITY?

Soft tissue procedures used to treat chronic scapholunate ligament injuries fall into two categories. The first include a capsulodesis, alone, or with an accompanying direct repair. The second involve some form of tendon graft augmentation. It is an obvious pre-requisite for either of these approaches that the scapholunate instability itself is reducible and that there is no evidence of osteoarthritis or, indeed, cartilage wear. Certainly, soft tissue reconstructions are contraindicated if the dissociation is fixed, or in the presence of arthritis. If there is any doubt about this, it is essential that the patient undergoes an examination under X-ray control and wrist arthroscopy, if necessary.

Capsulodesis was first described by Blatt (1987), who fashioned a ligament from the dorsal capsule of the wrist, which, when inserted into the dorsal aspect of the distal scaphoid, acted as a checkrein to flexion (Fig 13). The rationale behind this procedure is that, whilst no attempt is made to reduce the persistent scapholunate dissociation, the attachment distally prevents scaphoid malrotation. It should be noted, however, that many surgeons now combine this capsulodesis with a direct repair of the scapholunate interosseous ligament.

In 1987, Blatt both described his technique and reported the long-term results in 12 patients. All patients recovered full extension with less than 20° loss of wrist flexion. Grip strength improved to 80% of normal.

Subsequent to this, there have been a number of other reported series, the first by Lavernia et al. (1992), who described the results of direct scapholunate ligamentous repair supported by a dorsal radio scaphoid capsulodesis. The results of 21 patients treated by this technique between 1972 and 1988 were reported. Grip strength, pain and X-ray appearances improved in all cases. There was, however, some reduction in movement, particularly palmar flexion, which averaged 11.5°. Only one patient had to change his occupation after surgery and, at follow-up, three had X-ray findings of degenerative arthritis. Otherwise, there were no significant complications. This favourable outcome was further supported by Wintman et al. (1995).

Further work by Schweizer and Steiger (2002) from Switzerland, Szabo et al. (2002) from the United States and Busse et al. (2002) from Germany also reported satisfactory results. Movements of the wrist, however, were reduced, as was grip strength, to a minor degree. Schweizer and Steiger (2002) identified early arthritis, particularly affecting the mid carpal joint, in five cases. Busse et al. (2002) noted that 5 out of 12 of their patients needed further surgery because of persistent pain.

An alternative view was expressed by Wyrick et al. (1998), when they reviewed their experience of 17 patients with a mean follow-up of 2½ years. At final follow-up, no patient was pain free and wrist movement was only 60% of normal, with grip strength 70% of that of the opposite side. Radiologically, there was no significant difference between X-ray parameters prior to surgery and at follow-up. Overall, only two patients had an excellent or good outcome, as graded by Green and O’Brien (1980). They concluded that repair of the scapholunate ligament with dorsal capsulodesis failed to provide satisfactory results. Similarly, Deshmukh et al. (1999) reviewed 44 cases of chronic scapholunate dissociation treated by Blatt’s dorsal capsulodesis alone with a minimum follow-up of 2 years. Postoperatively, again, there were significant reductions in wrist movement, particularly palmar flexion, as well as grip strength. Overall, using a locally described scoring system, only 39% were satisfied and 61% partially satisfied with the outcome of the procedure. Forty six per cent were graded objectively as a fair or poor outcome. The factors that influenced these figures were...
delay to surgery and, also, an outstanding compensation claim. Complications included three cases of CRPS 1 (Algodystrophy or Reflex Sympathetic Dystrophy) and two cases of pin tract infection. Finally, in an additional radiological study, it was noted that patients who had a high “column row” index, that is those patients with scaphoids that normally flexed rather than translated on ulnar deviation, had better results than those that predominantly translated.

Scapholunate stabilisation using tendon grafts as an augmentation, or an alternative for ligament reconstruction, has been used for many years (Dobyns et al., 1975; Glickel and Millender, 1984). Most share a common goal, that is to recreate a scapholunate ligament and, as such, a more normal scapholunate relationship. Generally, however, these are technically demanding procedures. Another disadvantage of tendon graft stabilizations, in general, is that the modulus of elasticity of the original ligaments of the wrist is much greater than that of any tendon graft. As a consequence, this may result in an alteration, or stiffening, of the normal intercarpal kinematics.

Almquist et al. (1991) reported the results of a four bone ligamentous weave reconstruction which incorporated a long strip of the extensor carpi radialis brevis tendon with an average follow-up of almost 5 years. The patients had a grip strength of 73% of the uninvolved side, with an average of 52° of extension and 37° of flexion. Eighty-six per cent of patients returned to their pre-injury activity, including heavy labour in some cases. Pre-operatively, X-rays of the scapholunate intervals measured greater than 4 mm, whereas, at review, these measured 3.3 mm. There was no X-ray evidence of advancing arthritic change.

In 1995, Brunelli and Brunelli described their technique of treating scapholunate dissociation. This entailed using a slip of the flexor carpi radialis (FCR) tendon, pulled through the distal pole of the scaphoid to exit on the dorsal aspect, then be inserted into the dorsal ulnar side of the radius. This technique has subsequently been modified by Van Den Abbeele et al. (1998). In this author’s technique, the tendon slip was inserted into the dorsum of the lunate or tunnelled under the dorsal radio-lunotriquetral ligament and sutured back on itself (Fig 14). This modification was made to avoid tethering and, as a consequence, excessive loss of flexion at the radiocarpal joint. Of the 22 patients who underwent this procedure, 17 had complete relief of pain. Movements postoperatively were reduced, with on average 10° loss of both flexion and extension. Otherwise, there was little change in grip strength or function. The authors have recently reviewed their longer term outcome in 162 patients over 10 years. On average, 78% of patients were very satisfied, or satisfied, with the procedure and 88% said they would have the operation again. In addition, the vast majority of patients reported a statistically significant reduction in pain and an average of 79% of grip strength of the opposite side and 74% of the flexion extension arc. Unfortunately, 24 of the 162 patients were obliged to change their occupation to one of lighter work and six patients had undergone further surgery.

On the ulnar side of the wrist most surgeons prefer to treat chronic lunotriquetral instability by arthrodesis. Soft tissue reconstructions, including direct repair or reinsertion of the ligament together with ligament reconstruction with tendon graft, have all been tried. At Wrightington Hospital, we have used a slip of extensor carpi ulnaris tendon passed through a tunnel in the triquetrum bone and sutured back on to itself as a form of dynamic stabilisation for some time. The results of this technique were reported by Shahane et al. (2005) (Fig 15). Of the 46 patients reviewed, 29 had excellent or good, 11 satisfactory and only 6 poor results, using the Mayo wrist score. Eighty-seven per cent of patients asked said that the surgery substantially improved the condition of their wrist.
At the midcarpal joint, various soft tissue reconstruction procedures have been tried, including palmar capsular reefing, dorsal radiocarpal capsulodesis, advancement of the ulnar arm of the arcuate ligament and triquetrohamate ligament reconstruction. Lichtman et al. (1993) reported their results with these procedures and concluded, generally, that they were inferior to a limited midcarpal arthrodesis.

17. WHAT BONY PROCEDURES ARE AVAILABLE TO TREAT CHRONIC SCAPHOLUNATE LIGAMENT INJURY?

The indifferent results of ligament reconstruction have persuaded many surgeons to perform intercarpal arthrodeses, the most logical of which is scapholunate arthrodesis. Hom and Ruby (1991) reported their experience of this procedure and found that, only one of seven patients, ultimately, attained radiographic fusion and three still had significant symptoms. Alnot et al. (1992) had similar problems, although Zubairy and Jones (2003) found that 10 of the 13 patients were subjectively satisfied with the treatment, although only 4 achieved fusion.

In view of these difficulties, attention turned to the STT joint (Fig 16). Watson and Hempton (1980) found that STT fusion was more readily obtained and was successful in controlling rotatory subluxation of the scaphoid, preserving 80% of the normal range of flexion/extension and 66% of the normal range of radial and ulnar deviation. Such good results were reported again by these authors in a further publication in 1999. Kleinman et al. (1982) also reported good results with this procedure in that 9 of their 12 patients returned to pre-injury activities, without wrist pain and with 80% of the pre-operative range of motion. More recently, however, Eckenrode et al. (1986) reported less good results. Voche et al. (1991) found that their patients only maintained 60% of their pre-operative range of motion and that X-rays revealed styloid impingement in 34% of cases. Fortin and Louis (1993) also showed that 8 out of 14 patients had significant residual symptoms and 11 had complications, including radiocarpal and trapeziometacarpal arthritis, as well as non-union.

Scaphocapitate arthrodesis has the same effect, but is easier to perform (Fig 17). Pisano et al. (1991) found that grip strength was good, although it reduced wrist movement, particularly radial deviation. Only 2 of 17 patients required re-operation for non-union.

Whilst lunotriquetral dissociation occurs less commonly than scapholunate dissociation, it can also, on occasion, require surgical treatment. Reagan et al. (1984) found that simple immobilisation was only useful for acute injuries, with capsulodesis, tenodesis or arthrodesis being reserved for chronic cases. Pin et al. (1989) reported their results of lunotriquetral fusion (Fig 18) and found that three patients had persistent pain, although fusion occurred in all 8 cases. In addition, whilst range of motion was preserved, only 50% of grip strength was maintained. Kirschenbaum et al. (1993) also advocated fusion, although Nelson et al. (1993) reported problems of non-union and

Fig 16 Scapho-trapezio-trapezoid (STT) fusion.

Fig 17 Scapho-capitate fusion.
recommended using a Herbert screw as well as a K-wire for fixation and a cast for at least eight weeks. Finally, Sennwald et al. (1995), in a review of 33 patients, concluded that lunotriquetral fusion cannot be considered as a routine procedure and that results are unpredictable.

With regard to the midcarpus, Lichtman et al. (1981) originally described this instability and investigated its pathomechanics. They also described a diagnostic test, specifically 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 a volar collapse deformity. Laboratory studies have shown volar subluxation of the capitate and hamate on the lunate and triquetrum. Johnson and Carrera (1986) identified attenuation of the radiocapitate ligament as the cause of this condition and advocated tightening the ligament to obliterate the space of Poirier. Generally, however, soft tissue reconstructions have usually failed and midcarpal arthrodesis is preferred (Lichtman et al., 1993). Siegel and Ruby (1996) reported their results of midcarpal arthrodesis in 11 patients followed up for an average of 5.2 years. Four of the 11 patients had ultimately undergone total wrist fusion for continuing pain. Seven patients, however, reported some improvement and were able to return to work. Overall wrist movement was 50% and grip strength 65% of their normal side. Rao and Culver (1995) reported their results of 11 wrists in 10 patients which had undergone triquetrotamate arthrodesis for symptomatic midcarpal instability. At follow-up, averaging 26 months, there were 6 good to excellent, 3 fair and 2 poor results. Compared to the contralateral side, range of motion averaged 55% flexion, 69% extension, 61% radial deviation and 64% ulnar deviation. Grip strength averaged 64% of the normal wrist. The author ended with a cautionary note that the stability provided by this arthrodesis failed to control symptoms in almost half of the cases.

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

The principal difficulty with small bone arthrodesis is non-union, as one would expect. This was addressed by Larsen et al. (1997), who undertook a meta-analysis of the literature. In the published literature, scapho-trapezium-trapezoid arthrodesis has a 14% non-union rate, lunotriquetral arthrodesis has a 27% non-union rate and scapholunate arthrodesis has a 47% non-union rate.

18. WHAT OTHER PROCEDURES ARE SOMETIMES UNDERTAKEN?

Because of the complexity of both soft tissue and bony reconstruction for carpal instability, the results are often unpredictable. A number of surgeons have, therefore, advocated alternate procedures. Conyers (1990) performed an imbrication of the palmar ligaments and chondrodesis between the scaphoid and lunate for chronic scapholunate instability and reported improvement of the pinch and grip strengths and of the range of motion.

Ruch and Poehling (1996) reported a satisfactory outcome in 14 patients with isolated partial scapholunate and lunotriquetral ligament injuries who had undergone arthroscopic debridement with early mobilisation. Weiss (1998) reported their results of 43 wrists which underwent not only a diagnostic wrist arthroscopy but also a debridement of the torn area using a resector, or a suction punch, for a mixture of isolated scapholunate or lunotriquetral ligament injuries. Surgery was undertaken, on average, 8 months after injury. At an average follow-up of over 2 years, 10 of the 15 patients with complete scapholunate ligament injuries reported a complete resolution of symptoms, although five patients had persistent pain and required subsequent reconstruction. Of the 13 patients who had a partial scapholunate ligament injury, 11 reported complete resolution of symptoms. Whether this was maintained long-term remains uncertain.
Shin et al. (1998) investigated the possibility of reconstructing the scapholunate ligament with a bone-retinaculum-bone autograft preparation from Lister’s tubercle. Essentially, this was a cadaveric study to assess the tensile strength of this construct against that of the normal scapholunate ligament. The results indicated that, although this autograft was significantly weaker with a failure load of less than a quarter of the normal ligament, considering the cross sectional areas, the failure stress was more equal. Hofstede et al. (1999) examined the biomechanical properties of 9 dorsal tarsal ligaments from the foot. They concluded that the medial dorsal cuneonavicular ligament was the strongest and, therefore, the most suitable for use as an autograft for reconstruction of the scapholunate ligament.

Weiss (1998) reported the early results using a bone-retinaculum-bone autograft for chronic scapholunate ligament reconstruction. The graft used initially was from the third dorsal compartment, although, subsequently, and in the majority of cases, the graft was taken from Lister’s tubercle, this being technically easier. The bone blocks were then inserted into the scaphoid and lunate, which were reduced and held by K wires. At follow-up at an average of 3.2 years, 12 of the 14 patients with dynamic instability had no pain and two had pain following heavy activity only. All recovered satisfactory ranges of motion and grip strength and none of the patients were dissatisfied. Thirteen of the 14 returned to their former work. Of the five patients with static scapholunate dissociation, two had continuing pain postoperatively and one had pain after heavy activity. Recovery of movements and grip strength were not as good as in the dynamic group, grip strength being only half of that of the contralateral side. In this group, two patients were dissatisfied and underwent further surgery. Complications occurred in six patients, including skin breakdown over a prominent K-wire and neuropraxia involving the superficial branch of the radial nerve in five patients, which persisted in two.

Weinstein and Berger (2002) reviewed their experience in 19 patients who had isolated anterior and posterior interosseous neurctomies for chronic wrist pain and no previous, or concurrent, wrist surgery. At an average of 2.1 years follow-up, 80% of the patients reported a decrease in pain, 45% reported normal or increased grip strength and 73% of patients had returned to work. Three patients had undergone additional procedures. These authors felt that failures tended to occur in the first postoperative year.

19. WHAT ARE THE LONG-TERM EFFECTS OF CARPAL INSTABILITY?

The natural history of an isolated scapholunate ligament injury remains unclear. Although Harrington et al. (1987) and Watson et al. (1997, 1999) stated that secondary osteoarthritis in the form of a scapholunate advanced collapse (SLAC) wrist is an inevitable consequence of a scapholunate disruption there is still little conclusive evidence of this. Larsen and Brondum (1993) performed a retrospective review of 18 cases of carpal instability diagnosed by clinical and radiological means, most of which had been treated surgically. Their mean follow-up was 9 years, with a range from 1 to 20. At review, 4 of their 18 cases had undergone a wrist arthrodesis and another 4 had radiological signs of significant osteoarthritis. Twelve of the 18, however, were satisfactory in terms of pain and grip strength, despite persistent radiographic instability in nine.

The long-term effects of instability on the wrist were also evaluated by Bleven et al. (1989), who used pressure-sensitive films to record changes in the radio-scaphoid and radiolunate contact areas after sequential ligament section in cadavers. 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. In our series of patients with arthroscopically proven interosseous scapholunate injury without any radiological signs of DISI or scapholunate gapping, there was no real evidence of any rapid deterioration to radiocarpal osteoarthritis over an average of 7 years, although patients remained symptomatic (O’Meeghan et al., 2003).

20. CAN THESE BE TREATED?

The loss of motion and altered biomechanics which result from either untreated carpal instability, or, sometimes, its treatment may give rise to symptomatic secondary osteoarthritis in the long term. STT fusion and scaphocapitate fusion have been found to produce a significant reduction in range of motion. Both procedures increase the sliding motion of the lunate on the radius such that Garcia-Elías et al. (1995) and Viegas et al. (1993) found that virtually all the load was transmitted to the scaphoid fossae. Other fusions, viz. scapholunate, scapholunocapitate and capitohamate, all distributed the load more equally through both the scaphoid and lunate fossa. The position of the scaphoid in STT fusions is crucial. 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 a more anatomical position, STT 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 capitohamate joint, but sparing the radiolunate joint (Fig 19). They recommend reduction of the so-called
DISI deformity, excision of the scaphoid and fusion of the capitate, hamate, lunate and triquetrum (a so-called ‘Four-Corner Fusion’) (Fig 20). Of the 19 patients treated, 18 had some pain relief while maintaining an adequate range of motion. Krakauer et al. (1994) operated on 55 patients with SLAC and obtained the best results with scaphoid excision and a ‘four-corner fusion’. Saffar and Fakoury (1992) compared proximal row carpectomy with partial wrist arthrodesis and found that the latter gave better results.

The results of radioscopypholunate arthodesis and distal scaphoidectomy for the treatment of radiocarpal degenerative osteoarthritis were reported by Garcia-Elias et al. (2005). This procedure was undertaken for patients who, predominantly, had an intraarticular fracture of the distal radius and continuing incongruity. Two patients, however, had suffered a perilunar fracture dislocation. The scaphoid and lunate were arthrodesed to the distal radius and the distal quarter of the scaphoid removed. At an average follow-up of just over 3 years, complete pain relief was obtained in 10 patients with a significant reduction in the other six. Movement was $32^\circ$ of flexion, $35^\circ$ of extension, $14^\circ$ of radial deviation and $90^\circ$ of ulnar deviation. Two patients, ultimately, did develop secondary midcarpal degenerative change.

References


