The concept of carpal instability has evolved considerably over the past few years. Initially, the term ‘instability’ was considered to be synonymous with ‘malalignment’. A wrist was regarded as unstable when there was an alteration of the sagittal and/or anteroposterior alignment of the carpal bones beyond what was judged to be normal. Based on this, four major types of carpal malalignment were recognised: 

Dorsal intercalated segment instability (DISI). The lunate, regarded as an intercalated segment between the distal row and the forearm bones, is abnormally extended relative to its proximal and distal links.

Volar intercalated segment instability (VISI). In the sagittal plane the lunate appears abnormally flexed.

Ulnar translocation. The proximal row is abnormally displaced (rotated or translocated) relative to the radius in an ulnar direction.

Dorsal translocation. Due to a malunited fracture of the radius, the carpus is subluxed in a dorsal direction.

These four types of instability could therefore always be diagnosed by plain radiography. A number of authors including Schernberg and Zdravkovic, Jacob and Sennwald have criticised this concept of instability since not every alteration of carpal alignment is pathological. Wrists showing congenital hyperlaxity often appear to be grossly malaligned and yet are frequently asymptomatic. These patients are able to cope effectively with most activities of daily living and seldom require treatment. It was therefore necessary to reconsider the definition of instability and exclude those patients whose carpal malalignment is simply a variation of the normal. As a result, instability has been redefined as the inability to bear physiological loads with an associated loss of the normal carpal alignment.

CLASSIFICATION OF CARPAL INSTABILITIES
Many different conditions such as trauma, inflammation, infection or congenital disease may result in an unstable wrist. All may generate carpal instability (or carpal dysfunction) which can be classified into four major patterns:

1) dissociative carpal instability (CID);
2) non-dissociative carpal instability (CIND);
3) complex carpal instability (CIC); and
4) adaptive carpal instability (CIA).

CID occurs when there is major dysfunction between bones of the same carpal row, by fracture or ligament disruption. By contrast, when there is dysfunction between rows, this is classified as CIND. The ligaments usually

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affected in CID (scapholunate, lunotriquetral) are short, stiff and difficult to repair; in CIND they are longer, less stiff, and more easily repairable (triquetral-capitate, radiolunate, radiocapitate). 25

CID may be subdivided into proximal (scapholunate and lunotriquetral dissociations) and distal (capitate-hamate axial disruptions). Similarly, CIND may be subdivided into radiocarpal with rupture of several radiocarpal ligaments resulting in an ulnar translation of the carpus, and midcarpal with rupture of the triquetral-hamate-capitate ligament complex.

Both CID and CIND may be found together. This is not unusual and is classified as CIC. Perilunate dislocations, for instance, create a complex ligament injury at both the radiocarpal (radiolunate, radiocapitate ligaments) and intercarpal levels (scapholunate, lunotriquetral) which, if it does not heal properly, may result in a chronic scapholunate and lunotriquetral dissociation (CID patterns) and also an ulnar translation of the lunate (CIND pattern).

Finally, there is carpal instability the origin of which is not located within the wrist, but proximal or distal to it. Wrist alignment is altered, not because of an intrinsic cause, but as an adaptation to extrinsic pathology. These cases are classified as adaptive carpal instabilities (CIA) and a typical example is that secondary to a malunited distal radial fracture. 24

### TREATMENT OF CARPAL INSTABILITIES

There is no single treatment for carpal instability; the surgeon must be able to adapt to meet the needs of each individual. To guide this process Larsen et al. 25 proposed that six criteria should be investigated (Table I): chronicity (healing potential of the ligaments involved); constancy (dynamic or static); aetiology (traumatic, congenital, inflammatory); location (site of the major dysfunction); direction of the abnormal rotation and/or translocation of the carpal bones; and pattern of instability (CID, CIND, CIC or CIA). Careful assessment of these features will allow a rational decision for treatment.

**Proximal dissociative carpal instability (proximal CID).** The more common conditions causing this pattern of instability are: 1) unstable scaphoid nonunion; 2) scapholunate dissociation; and 3) lunotriquetral dissociation. 18 Other less frequent disorders which produce proximal CID, such as Kienböck’s disease and proximal fractures of the triquetrum, will not be discussed.

**Unstable scaphoid nonunion.** The scaphoid has been shown to be an important link between the proximal and distal rows with a stabilising role when the wrist is axially loaded. 1,2 and it is responsible for the synchronous movement of the carpus. 26 If the scaphoid is divided into two or more fragments, the distal portion tends to follow the movement of the distal row while the proximal fragment follows that of the proximal row. It is then no longer a link between the two rows.

The proximal part follows the unconstrained lunate and triquetrum by rotating into extension relative to both the radius and the capitate. In this situation wrist movement is not normal and its forces cannot be transferred adequately. 27 The resultant instability is proximal CID which typically causes a DISI pattern of carpal malalignment.

The surgeon not only needs to be able to stabilise the fragments, but also to restore the correct anatomical relationship between the scaphoid and the rest of the carpus. Usually, the scaphoid shows atrophy of its palmar cortex. To correct this problem a wedge-shaped graft must be used and its dimensions calculated from plain radiographs or, more accurately, by tomography in different projections (Fig. 1). Often, not only sagittal angulation but also a certain degree of axial rotation must be overcome. 30 The best anatomical reference for correcting rotational deformity is the articular surface to the capitate. In such cases, a dorsal approach is better than a palmar. 31 It allows more accurate control of the angular rotation ensuring adequate scaphocapitate congruity, but at the expense of greater difficulty in placing the palmar graft.

**Scapholunate dissociation.** A complete disruption of the ligaments between the lunate and scaphoid also results in a

### Table I. Analysis of carpal instability, modified from Larsen et al.

<table>
<thead>
<tr>
<th>Chronicity</th>
<th>Constancy</th>
<th>Aetiology</th>
<th>Location</th>
<th>Direction</th>
<th>Pattern</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acute &lt; 1 week (maximum primary healing potential)</td>
<td>Static irreducible</td>
<td>Congenital</td>
<td>Radiocarpal</td>
<td>VISI rotation</td>
<td>Dissociative carpal instability (CID)</td>
</tr>
<tr>
<td>Subacute 1 to 6 weeks (some healing potential)</td>
<td>Static reducible</td>
<td>Traumatic</td>
<td>Proximal intercarpal</td>
<td>DISI rotation</td>
<td>Non-dissociative carpal instability (CIND)</td>
</tr>
<tr>
<td>Chronic &gt; 6 weeks (little primary healing potential)</td>
<td>Dynamic</td>
<td>Inflammatory</td>
<td>Midcarpal</td>
<td>Ulnar translation</td>
<td>Complex carpal instability (CIC)</td>
</tr>
<tr>
<td>Predynamic</td>
<td>Neoplastic</td>
<td>Distal intercarpal</td>
<td>Palmar translation</td>
<td>Dorsal translation</td>
<td>Adaptive carpal instability (CIA)</td>
</tr>
<tr>
<td>Iatrogenic</td>
<td>Carpometacarpal</td>
<td>Proximal translation</td>
<td>Specific bones</td>
<td>Distal translation</td>
<td></td>
</tr>
</tbody>
</table>
proximal CID-DISI pattern of carpal collapse. The scaphoid, devoid of proximal constraints, rotates around the radiocapitate ligament leading to dorsal subluxation of its proximal pole. The lunate, by contrast, follows its natural tendency towards extension which is further enhanced by the extension moment transmitted by the triquetrum. Experimental studies have shown that the key structure preventing scapholunate dissociation, and therefore the key structure to be repaired, is the dorsal portion of the scapholunate interosseous membrane. Secondary constraint is produced by the distal scaphotrapezial ligamentous complex. Most authors agree that the best treatment for an acute scapholunate dissociation is repair of the ruptured ligaments and temporary stabilisation of the scaphoid by Kirschner (K) wires. This is achieved by approaching the carpus dorsally and creating a proximally-based flap over the scapholunate interval. The flap is later used as a dorsal capsulodesis to neutralise further the tendency of the scaphoid to collapse into flexion. The viable remains of the dorsal scapholunate ligament are usually found attached to the lunate having been avulsed from the scaphoid. The ligament can be reattached to the scaphoid by non-absorbable transosseous sutures while the adjacent joints are blocked temporarily with K wires (Fig. 2) and immobilised in a cast for at least two months.

There is also agreement on the management of chronic scapholunate instability with extensive degenerative changes at the radioscaphoid and lunocapitate joints. This is best treated by midcarpal fusion with resection of the scaphoid, the so-called SLAC procedure.

There is controversy about treatment of the intermediate types of chronic scapholunate dissociation with no degenerative changes of the periscapholunate joints, but with substantial ligamentous atrophy precluding a reliable repair. Surgical fusion of either the scaphoid-trapezium-trapezoid or the scaphocapitate joints has been suggested as treatment and several reports have recorded promising long-term results. The technical details need to be carefully followed, however, otherwise the complications are unacceptably high. When these fusions are not perfectly planned and executed, nonunion and/or secondary radio-scaphoid osteoarthritis may often occur. Another option is to fuse the midcarpal joint (Fig. 3). This is especially indicated when there is extensive cartilage wear at the scaphoid-lunate-capitate joints.

Several methods of scapholunate and scaphotrapezial
Joint stabilisation using adjacent wrist motor tendons have been reported. The tenodesis procedure of Brunelli and Brunelli, which is a double (distal and proximal) scaphoid stabilisation using a portion of flexor carpi radialis, has shown good mid-term results. A longer follow-up will be necessary to know if these tendon reconstructions will resist the high stresses which normally concentrate on these joints. Previously reported tenodesis procedures have been found to give poor long-term results.

**Lunotriquetral dissociation.** Complete disruption of the lunotriquetral ligaments results in a dissociative VISI pattern of carpal collapse if it is associated with insufficiency of the dorsal radiotriquetral ligament. The scaphoid forces the unconstrained lunate into palmar flexion, while the triquetrum extends and translocates proximally (Fig. 4). When acute cases are seen, treatment must include anatomical reduction and repair of both the intrinsic and extrinsic ligaments involved. Unfortunately, there is often misdiagnosis on presentation when the healing potential of the involved ligaments is greatest. When this occurs, there is already adjacent cartilage degeneration and/or a triangular fibrocartilage deterioration. In such circumstances, both the ulnocarpal and lunotriquetral problems should be addressed. The latter are best managed by a lunotriquetral arthrodesis using K wires or screw fixation.

**Dissociative distal carpal instability (distal CID).** This is a very unusual problem and is due to rupture of the transverse intercarpal ligaments binding the bones of the distal row, usually caused by a dorsopalmar crush or a blast injury. The two columns into which the distal row has been divided tend to separate from each other with the subsequent flattening of the palmar concavity, giving rise to so-called axial fracture-dislocation. Usually, one of the two columns appears grossly displaced while the other remains normally aligned with the radius. Depending on the direction of displacement this injury has been classified into three subgroups: axial-radial, axial-ulnar or axial-radial-ulnar instability. Treatment consists of open reduction of the displaced segment and ligament.
repair (which is only possible in acute cases) or surgical fusion of the involved joints.

**Non-dissociative radiocarpal instability (radiocarpal CIND).** The most common condition leading to a radiocarpal non-dissociative instability is malunion with angular displacement (commonly dorsal) of the distal radius. Less frequent is insufficiency of the extrinsic radiocarpal ligaments (traumatic, inflammatory or congenitally lax).

**Distal radial malunion.** If there is a dorsally malaligned distal radius but the radiocarpal ligaments are intact, the proximal carpal row remains aligned with the distal radius and a DISI type of angulation develops at the midcarpal joint, sufficient to align the hand and the forearm \(^{46}\) (Fig. 5). This is not a true carpal instability since there is no intracarpal pathology, but it is an adaptive state \(^{24}\) with CIA pattern according to the classification scheme already described. By contrast, if the radiocarpal ligaments have been disrupted in association with the fracture, or if they have been progressively stretched after the injury, the carpus may sublux or occasionally dislocate in a dorsal, dorsoradial or palmar direction depending on the type of the fracture. This is an example of a radiocarpal non-dissociative instability. \(^{21,47}\)

If the malalignment is simply adaptive, then only a corrective osteotomy of the radius is necessary. If there is a secondary ligament derangement in addition to malunion, ligament reconstruction or a partial arthrodesis (radiolunate or radioscapoholunate) will be required as well as the corrective osteotomy.

**Midcarpal non-dissociative instability.** The triquetrum under load is normally pulled into extension by the palmar triquetrum-hamate ligaments, a movement which is opposed by flexion of the loaded scaphoid. \(^{18}\) If this midcarpal ligament is torn, absent or lax, a reverse phenomen-
on occurs. The lunate is forced by the scaphoid into palmar flexion, thus placing the distal row palmar to the flexion/extension axis of the wrist. The triquetrum is also constrained into palmar flexion resulting in a non-dissociative VISI deformity of the proximal carpal row. During wrist movement the proximal row remains palmar flexed throughout the whole range except when this is fully ulnar deviated, when the triquetrum-hamate joint is fully engaged and induces the proximal row to rotate suddenly into extension, producing a quite typical snap. Many different types of soft-tissue reconstruction have been suggested to correct this problem (palmar capsulorrhaphy, tenodesis) most of which have significant rates of complications. When causing symptoms and poorly controlled by conservative measures, it is best treated by partial or total fusion of the midcarpal joint. Combined radiocarpal and midcarpal CIND. Louis et al described a type of carpal instability in which dorsal subluxation of both the midcarpal and radiocarpal joints can be reproduced by manual traction and dorsal translocation of the distal carpal row. This is the so-called CLIP condition (capitate lunate instability pattern) which may be responsible for persisting pain and clicking in the midcarpal region and also snapping especially when lifting objects. In this type of instability there is both a radiocarpal and midcarpal ligament insufficiency, commonly due to congenital laxity. Operative treatment for these cases is seldom necessary, but in selected patients augmentation of the dorsal scaphotrapezial ligament with a portion of extensor carpi radialis may help to relieve the symptoms.

Carpal instability complex. The most typical example of a combined instability occurs after the failed treatment of a perilunate dislocation. This injury usually implies severe damage to both the intrinsic (scapholunate and lunotriquetral) and extrinsic radiocarpal ligaments. Failure to obtain stability of the joints of the proximal row may result in a chronic CID type of carpal collapse. Furthermore, if the damaged extrinsic radiocarpal ligaments do not heal or remain inefficient, there may be a tendency to development of radiocarpal CIND (ulnar translocation of the ulnar side of the carpus). Radiologically, this complex instability presents as a palmar flexed scaphoid, widening of the scapholunate joint space, and an ulnar translocated, dorsiflexed lunate. These patients require surgical stabilisation of both causes of the instability to obtain a reasonably good outcome. This can be achieved by midcarpal fusion with a tightening of the dorsal and volar radiocarpal ligaments, or, in the case of substantial cartilage wear, by a formal wrist fusion.

REFERENCES