WRIST

Management of wrist instability

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Summary
The wrist is a complex structure which has evolved to allow precise and controlled motion in all 3 planes, thus allowing the hand to be positioned perfectly. This paper reviews the normal anatomy of the wrist and how it can go wrong, resulting in static or dynamic instability. A good history, clinical examination, appropriate investigations and the use of classification systems help to localize this instability thus allowing an appropriate management plan to be formulated. Finally, various treatment options are described and explained.

Introduction
The wrist is a complex joint consisting of co-articulation of the carpal bones amongst each other and also with the distal radius and ulna. It permits motion in all 3 planes and allows these complex patterns of motion to take place under considerable strain, for example, when twisting. There are 10 bones involved along with the corresponding ligaments, capsule and tendons. The wrist joint functions is a kinematic linkage system and has evolved in this way to allow the hand to adjust its position in relation to the forearm thus placing it in the best possible position in order to perform a particular function.

The way in which the carpal bones are connected to each other and to the distal radius results in certain patterns of carpal bone motion specific to the direction of motion of the hand with respect to the forearm. These unique patterns of motion are a result of carpal bone geometry, ligament function and muscle activity. Optimal wrist function requires stability of all these carpal components in all joint positions under static and dynamic conditions.

Instability is a condition that arises when there is altered joint kinematics whereby one or more carpal bones moves in an abnormal pattern as a result of bony injuries, intrinsic and/or extrinsic ligamentous injuries or joint laxity. Thus the wrist is rendered unstable to external forces of pinch and grasp.

Functional anatomy, classification and aetiology
Stability of the wrist is closely linked to its functional anatomy. The shape of the carpal bones and the extrinsic and intrinsic carpal ligaments are important in maintaining stability. The two important ligament support systems are the extrinsic wrist ligaments and the intrinsic or interossous ligament system.
The extrinsic ligament system includes the proximal and distal volar radiocarpal ligaments that consist of a series of inverted V shaped ligaments with the tip of the V at the capitate and the ligament fibres interconnecting the proximal and distal carpal rows with the distal radius. The radioscaphocapitate ligament (RSCL), which extends from the radial styloid process across a groove at 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 (LRL), which lies parallel to the RSCL, extends from the palmar rim of the distal part of the radius to the radial margin of the palmar horn of the lunate. The dorsal radiocarpal ligaments (DRCLs) are weaker and are centred on the trapezium (Fig. 1).

The intrinsic system consists of the interosseous ligaments of the wrist that connect the individual carpal bones. These interosseous ligaments include the scapholunate (SLL) and the lunotriquetral ligaments (LTLs) that are recognised as the most important stabilizing structures of the proximal carpal row. The thickest and strongest region of the SLL is located dorsally and that of the LTL is located on the palmar aspect.

Numerous studies have demonstrated that interosseous ligament injuries alone can give rise to wrist instability. This instability is further increased when the extrinsic ligaments and/or bony injuries are involved.

Kinematics

Several theories of wrist stability have been proposed over the years. These include the columnar or vertical carpus theory, the proximal row independence and the oval ring theories.

However, the following 5 concepts are widely accepted at present:

1. The distal articular surface of the radius, the triangular fibrocartilage complex (TFCC) and the distal ulna form the base for radiocarpal function.

2. The distal row of carpal bones acts as a rigid body in which the trapeziums, trapezoid, capitate and hamate are tightly conjoined.

3. The proximal carpal row, which consists of the scaphoid, lunate and triquetrum is a mobile and inherently unstable intercalated segment, which allows the hand to adjust its position relative to the forearm, as its position is relative to the spatial configurations of the radius, TFCC and ulna proximally and the rigid distal carpal row distally.

4. Thus due to the above described bony articulations, ligamentous support is essential for stability of the wrist. The ligament system comprises the short, intrinsic interosseous ligaments, the longer, extrinsic intraarticular ligaments and the extra-articular ligamentous structures.

5. The proximal carpal row flexes in wrist radial deviation and extends in ulnar deviation.

Classification

Classification of carpal Instability has been attempted by numerous authors, most recently by the International Wrist Investigators Workshop (IWIW) in order to assist in the diagnosis and treatment of this condition. Unfortunately, there are plethora of confusing classifications that are not helpful in the everyday clinic. Therefore we have summarised the salient points.

The carpus is considered unstable if it exhibits symptomatic malalignment, is not able to withstand loads, and does not have normal kinematics during any portion of its arc of motion. In order to classify a particular carpal instability, the clinical, radiological and anatomical findings must be taken into consideration. The first two can be obtained in the outpatient setting but the anatomical nature of the instability is best ascertained with MRI or during wrist arthroscopy. These newer investigations reveal more subtle degrees of instability.

First the instability, once detected, can be classified as static or dynamic. Static instability is defined as carpal malalignment that can be detected on standard posteroanterior and lateral radiographs. Dynamic instability is defined as carpal malalignment that is reproduced with physical examination manoeuvres and/or when stress radiographs are performed. With dynamic instability the carpal bone malalignment is not detected on standard radiographs.

Secondly, the location of the instability (i.e. joint involved) must be identified. The carpus may be mal aligned between the two rows (intracarpal problem) or remain aligned whilst translating the radiocarpal level to a new position (extracarpal problem).

The Mayo Clinic Classification divides the intracarpal instabilities as CID), CIND, CIC or CIA that are described below

1. CID or Carpal Instability Dissociative involves the disruption of an intercarpal ligament within a carpal row. This can result in Dorsal Intercalated Segment Instability (DISI), Volar Intercalated Segment Instability (VISI) or Axial Carpal Instability (Figs. 2–4).
DISI is usually a result of disruption of the SLL or unstable fracture of the scaphoid. Other causes include Kienbock’s disease. Radiographic findings include a scapholunate angle greater than 60° on the lateral radiograph and a scapholunate gap of greater than 3 mm on a PA view with clenched fist (Terry Thomas sign), (Figs. 4a and b). There may also be a break in Gilula’s arc at the scapholunate interval and there may be a cortical ring sign or scaphoid fracture or hump back deformity of the scaphoid.

VISI involves the disruption of the LTL. Radiographic findings include a break in Gilula’s arc on the PA view, a radiolunate angle of greater than 15° and a scapholunate angle less than 30° on the lateral radiograph (Figs. 3a and b).

Axial Carpal Instability is secondary to violent trauma causing disruption within the proximal and distal carpal rows in a longitudinal fashion, resulting in either a dislocation or a fracture-dislocation, for example, a trans-scaphoid peri-lunate fracture dislocation. These injuries have been further classified by Garcia-Elias into axial-radial, axial-ulnar and combined (Figs. 5–7).

2. CIND or Carpal Instability Non-Dissociative is a result of ligamentous disruption leading to instability between rows (radiocarpal or midcarpal). Radiographic examination may reveal translation of the lunate ulnarly (>50%) off the lunate fossa of the radius. Mal-union of the distal radius may also result in CIND (Fig. 8).

3. CIC or Carpal Instability Combined, as its name describes, is a combination of the above-mentioned instabilities and is a result of ligamentous disruption both within and between rows. The most often quoted example of this is the perilunate dislocation. It is easily missed if one is not cognizant of this injury. Mayfield described 4 stages of perilunar instability (Fig. 9) proceeding from radial to ulnar around the lunate and disrupting the following joints:

(i) Scapholunate;
(ii) Scapholunate and Capitolunate;
(iii) Scapholunate, Capitolunate and Lunotriquetral and;
(iv) Complete lunate dislocation usually in the volar direction.

4. Extracarpal instabilities are classified as Carpal Injury Adaptive (CIA) which includes secondary changes in the carpus, which results from a non-union or mal-union of the distal radius. Any adaptive carpus, by definition can be treated by an extra carpal intervention that does not require surgery on the carpus but with time, an adaptive carpus may degenerate to a point where the intrinsic ligaments fail and a secondary CID pattern (intracarpal problem) is established.

Chronic Instability of the wrist may arise as a sequelae Avascular Necrosis (AVN) of one of the carpal bones, most commonly the lunate (Kienbock’s disease) or scaphoid (Preiser’s disease), Scaphoid Non-Union Advanced Collapse (SNAC) or Scapholunate Advanced Collapse (SLAC) (Figs. 10 and 11).
Therefore, when assessing an unstable wrist, the following factors should be taken into consideration:

A. Time since injury: Acute (0–3 weeks), subacute (3–8 weeks) and chronic (over 8 weeks).
B. Constancy: Predynamic, dynamic or static.
C. Aetiology.
D. Anatomic location.
E. Direction of instability.
F. Pattern for example, CID, CIND, CIC or CIA.

Aetiology

Trauma resulting in ligament injury and/or bony fractures is the main cause of wrist instability. However, occasionally, excision of dorsal wrist ganglia, which most often originate from the scapholunate interosseous ligament in young adults, has been shown to be associated with symptoms and signs of dynamic scapholunate instability\textsuperscript{10} (Table 1).

Rheumatoid arthritis, progressive ageing and attenuation of carpal ligaments and extrinsic malalignments can also cause instability and result in an adaptive carpus.

Diagnosis

History

A good history and clinical examination are the keys to a correct diagnosis. Detailed and directed questions on the symptoms should be asked, for example if the pain is radial, ulnar or central and if it is bilateral or unilateral. Also the presence of aggravating factors should be ascertained. Certain positions or actions, for example dorsiflexion/palmarflexion or radial/ulnar deviation may reproduce the pain. The presence of painful clicks or any weakness while performing certain manoeuvres should also be ascertained. If there is a history of injury, the mechanism of injury must be noted; for example, fall on the outstretched hand, hyperpronation or hyperextension injuries, etc.

Examination

Examination involves the usual look, feel, move sequence followed by grip and pinch strength assessment and special
tests (Table 2). It is particularly important to note if any area of clicking is associated with tenderness on palpation. The palpation is always carried out systematically, starting from the non-tender area.

Investigations

The Six Shot Series Radiographs are then made for wrists with suspected carpal instability. These include posterior-anterior (PA) neutral, PA ulnar deviation, PA radial deviation, PA neutral and clenched fist, lateral neutral and lateral clenched fist. The loaded clenched fist view is to rule out scapholunate instability. Then the carpal alignment is evaluated with Gilula’s method where interruption of the normal carpal arcs of either the proximal or distal carpal row indicates an instability pattern. The scapholunate angle is measured from the lateral radiograph.

CT scanning being a purely bone investigation has limited usefulness for instability.

MRI with gadolinium enhancement can be used to evaluate carpal ligament injuries but the results tend to be inconsistent. MRI is most useful for evaluating suspected osteonecrosis of carpal bones and tumours of bone or soft tissue. In addition, MRI is good for investigation of the ulnocarpal compartment, i.e. the TFCC (Table 3).

Figure 7 Trans-scaphoid peri-lunate fracture dislocation.

Although wrist arthrography is now obsolete, EUA and dynamic wrist fluoroscopy is a useful procedure because movements of all the carpal bones in relation to each other and in relation to the radius and ulna can be evaluated.

Diagnostic wrist arthroscopy is now the gold standard in many centres as the definitive diagnostic study for suspected carpal instability due to its increased accuracy. In addition, wrist arthroscopy can be a therapeutic procedure as well.

Diagnostic wrist arthroscopy includes an examination of both the radiocarpal and midcarpal joints. In the radiocarpal joint, probing of the scapholunate ligament, the lunotriquetral ligament and the TFCC is carried out. The volar carpal ligaments are assessed in a radial to ulnar direction to determine whether extrinsic ligament injury has occurred. The midcarpal joint is then examined and a diagnosis of partial or complete carpal ligament injury can be established on the basis of the ease of separation of the scaphoid from the lunate and of the lunate from the triquetrum. With wrist arthroscopy specific patterns of injury can be more accurately identified by direct visualisation. The treatment can then be focused on management of the specific ligamentous injury responsible for the pattern of instability visualised. There exist some arthroscopic wrist instability classifications which help determine the degree of instability.

Management and treatment

The treatment algorithm of wrist instabilities depends on whether the injury is acute or chronic and also on the patient’s occupation and demands on the wrist. Treatment is based on the time since injury, the age of the patient and the severity of injury because this influences prognosis and outcome.

Fractures of the scaphoid are best treated by open reduction and internal fixation (ORIF) with or without bone graft in the first instance. Criteria for instability include displacement greater than 1 mm, scapholunate angle greater than 60° and capitolunate angle greater than 15°, proximal pole fractures, vertical oblique fractures and comminuted fractures. However, if the fracture is minimally displaced then conservative treatment with a below elbow cast is preferred and has a 95% union rate.

For ligament injuries, conservative treatment with the use of static or dynamic wrist splints has a role in certain cases but the failure of conservative treatment, especially for SLL ligament tears is an indication for surgical intervention.

Broadly, surgical intervention is performed for 3 main categories of instability. For acute cases, repair fracture reduction is performed whereas for subacute cases, repair soft tissue reconstruction is performed. In chronic cases, reconstruction and/or salvage procedures are performed.

In acute cases of ligament disruption, for example, SLL dissociation with DISI, closed reduction and percutaneous pinning is the initial treatment of choice. If the position is unsatisfactory, ligamentous repair within 3 weeks of the injury (linkage procedure) is preferred and delayed repair can be performed up to 12 months after the time of injury.
However, successful repair depends on the identification of a substantial reparable SLL and a supple scaphoid which can be reduced without extensive dissection. A capsulodesis may be added to a ligament repair, for example if dorsal intercarpal ligament capsulodesis as described by Linschied.\textsuperscript{13}

Dorsal capsulodesis as described by Blatt\textsuperscript{14} is now of historic interest only although other methods of capsulodesis\textsuperscript{15} are the treatment of choice for wrists with dynamic scapholunate instability unresponsive to conservative treatment, which is common in adolescents and young adults. Other ligament stabilisation procedures include ligament tenodesis procedures\textsuperscript{14} or ECU or similar tenodesis procedures.\textsuperscript{14}

If the ligament is not repairable or the deformity is not supple, a stabilisation procedure such as a scaphotrapezial-trapezoid (triscaphe or STT) fusion is advised. Other bony reconstruction procedures designed to stabilise the carpus include four corner fusion, proximal row carpectomy, or for specific areas, scaphocapitate, scapholunate or triquetrolunate fusions for example.

Total wrist fusion is a good salvage operation of last resort. Wrist denervation is used as an adjuvant treatment to relieve pain.

**Scaphoid Non-Union Advanced Collapse or SNAC**

This is a result of non-union of scaphoid fractures and can lead to advanced collapse and progressive arthritis.

**Scapholunate Advanced Collapse or SLAC**

This is the most common form of wrist arthritis and it evolves in a predictable sequence. Causes include Keinbock’s and Preiser’s disease. Injury to the SL ligament and palmar radioscaphoid ligaments leads to a shift of the
pressure centroid of the scaphoid resulting in abnormal intraarticular contact between the scaphoid and the distal radius. Three distinct time-related degenerative changes occur in SLAC.

Stage 1: Joint space narrowing between the tip of the styloid process and distal outer aspect of the scaphoid.

Stage 2: Degenerative changes along the entire articular surface between the radius and scaphoid.

Stage 3: Narrowing of the capitolunate space with arthritis involving the radioscaphoid and capitolunate joints.

Initial treatment consists of NSAIDs, wrist splint and modification of activities. For wrists with stage 1 SLAC resistant to nonoperative measures, operative treatment is designed to stabilise the carpus.

For wrists with stage 2 and 3 degenerative changes, a motion preserving reconstructive procedure is indicated.

Table 1

<table>
<thead>
<tr>
<th>Causes of wrist instability</th>
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<tbody>
<tr>
<td>Trauma</td>
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<td>Dorsal wrist ganglia excision</td>
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<td>Rheumatoid arthritis</td>
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<tr>
<td>Age</td>
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<td>Extrinsic malalignments</td>
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Table 2

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<tr>
<th>Condition</th>
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<td>DeQuervain’s</td>
<td>Finklestein’s</td>
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<td>Scapho-lunate instability</td>
<td>Scaphoid shift (Kirk Watson), Scaphoid thrust,</td>
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<td>Scaphoid lift</td>
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<td>Midcarpal instability</td>
<td>Midcarpal shift, Pivot shift (Lichtman)</td>
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<td>Luno-triquetal instability</td>
<td>Ballotment (Regan), Klieman Shear Test, Compression</td>
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<td>Ulnar sided pathology</td>
<td>Ulnocarpal stress</td>
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<td>Pisotriquetral arthritis</td>
<td>Grind</td>
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<td>DRUJ instability</td>
<td>Piano key, Radio-ulnar drawer test, Compression, Dimple sign</td>
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<tr>
<td>ECU subluxation</td>
<td>ECU Snap Test</td>
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Operative treatment can be divided into acute soft tissue treatment, soft tissue augmentation, limited bony fusions or salvage procedures.

Soft tissue procedures include the modified Brunelli procedure, ECU tenodesis and wrist denervation.

Limited bony fusions include the radial styloidectomy or STT or scaphocapitate arthrodesis. The aim is to maintain the scaphoid in a normal alignment with regard to the longitudinal axis of the wrist thus ensuring that compressive and shear forces are transmitted through a normal radio-scapholunate articulation.

Salvage procedures include either a four corner fusion with scaphoid excision or a proximal row carpectomy. It is useful to perform an arthroscopic assessment prior to these procedures. Wrist arthrodesis is another option.

Conclusion

Wrist instability is a dynamic spectrum ranging from examples like the simple scaphoid fracture or single ligament laxity to the complex trans-scaphoid peri-lunate fracture dislocation or the SLAC wrist. There are various aetiologies for this range of pathologies and the most important clinical concept is to obtain an accurate history and examination in the clinic, which will then lead to the most appropriate investigations and management for that particular patient.

References

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