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Zaangażowanie Autorów
A – Przygotowanie projektu badawczego
B – Zbieranie danych
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E – Przygotowanie manuskryptu
F – Opracowanie piśmiennictwa
G – Pozyskanie funduszy

Author's Contribution
A – Study Design
B – Data Collection
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Jaiyoung Ryu(A,B,C,D,E,F,G), Patrick T. McCulloch(A,B,C,D,E,F,G)
Department of Orthopaedics, West Virginia Universit, USA

Understanding wrist instabilities

Key words: *wrist instabilities, diagnosis, pathophysiology*

SUMMARY

The wrist function is to position the hand optimally for specific tasks. To do so, the wrist must have a large arc of motion while maintaining its stability. The traditional row theory, and the columnar theory were developed to explain how the columns and rows affect wrist motion and stability. The paper discuses normal and pathologic interaction between carpal bones and their position. All kinds of wrist instability are precisely described. The article summarizes with some possibilities of treatment.

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Adres do korespondencji / Address for correspondence
Jaiyoung Ryu, M.D, Ph.D.
746 Poplar Woods Drive, Morgantown, WV 26505 U. S.A.
tel./fax: (304) 293-1312, e-mail: jryu@adelphia.net

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BACKGROUND

The function of the wrist is to position the hand optimally for specific tasks. To do so, the wrist must have a large arc of motion while maintaining its stability. Hip and shoulder joints have large arcs of motion, which are permitted by their fundamental design as ball and socket joints; their stability is maintained by the large muscles surrounding them. The wrist cannot utilize this strategy because it would become too bulky to function properly. Alternatively, the wrist maintains mobility and stability through multi--linked rows. Though each link in a row has a small range of motion, the wrist functions through the cumulative mobility of the assembled links. The links, however, decrease wrist stability somewhat because the level of instability of each link is also cumulated. To overcome this, the wrist is designed not only in multi-linked rows, but in columns of these rows. An et al. compared the wrist with a Rubik's cube, which also has rows and columns [1].

The traditional row theory, and the columnar theory, which was first proposed by Navarro then modified by Taleisnik were developed to explain how the columns and rows affect wrist motion and stability [2,3,4,5,6,7,8,9,10]. The scaphoid, which connects the proximal and distal rows, makes carpal kinematics and kinetics more complex. Linscheid and Dobyns introduced the slider-crank mechanism of the scaphoid to explain its role [11]. Lichtman et al. later proposed the ring concept where the proximal and distal rows are connected with radial mobile and ulnar rotatory links [12]. Craigen and Stanley observed that there are two kinds of people: one whose scaphoid stays vertical and translates through radioulnar deviation and the other whose scaphoid flexes with ulnar deviation [13]. Thus, they felt that carpal kinematics covered a spectrum from the row theory to the column theory. They reported that women were more likely to have column type wrists. Each theory has merit in explaining certain motions or certain stability/instability patterns. However, none fully explains wrist joint mechanics.

The senior author (JR) and his colleagues studied three-dimensional carpal rotation angles during normal wrist motion under physiologic conditions [14, 15]. The study revealed that the distal carpal bones move as a single kinematic unit. During wrist flexion/extension, the scaphoid moved independent of the lunate and triquetrum, and during wrist deviation, the triquetrum moved independently. Thus, wrist motion seems to be comprised of four kinematic units: the scaphoid, lunate, triquetrum, and the distal carpal row. The authors propose this 'Four Unit Concept' to describe carpal kinematics or instabilities, instead of rows, columns, or a ring [16].

Normal (Stable) Wrist

As described in the 'Four Unit Concept' above, very little movement occurs between the distal carpal bones (Fig. 1). The proximal carpal bones, on the other hand, do exhibit independent movement. Despite this independent movement, the scaphoid, lunate, and triquetrum are connected via volar and dorsal intrinsic and extrinsic ligaments. This explains the coordinated motion of the scaphoid, lunate and triquetrum. The pisiform is the only carpal bone with a tendon insertion (the flexor carpi ulnaris).

The wrist is normally in equilibrium. The head of the capitate is the point around which flexion, extension, radial deviation and ulnar deviation occurs. The lunate, just proximal to the capitate, acts as an innocent bystander. The scaphoid sits within the scaphoid fossa of the distal radius and is in a „tug of war” the triquetrum.

The scapholunate (SLIL) and lunotriquetral (LTIL) interosseous ligaments unify the motions of proximal carpal bones while each of them pulls in opposite directions. The scapholunate (SL) ligament is strongest dorsally, which gives it a mechanical advantage to pull the lunate into flexion; the lunotriquetrial (LT) ligament is strongest volarly, giving it a mechanical advantage to pull the lunate into extension [17,18,19].

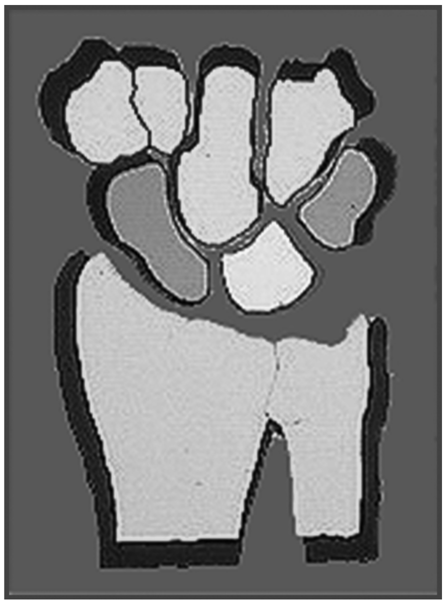

Fig. 1. The 'four unit concept', derived from a carpal kinematic study that showed the distal carpal bones moved as a single unit while the scaphoid, lunate, and triquetrum moved independently. It is proposed that this concept be used in describing normal or pathokinematics of the wrist, as well as stability and instability of the wrist.

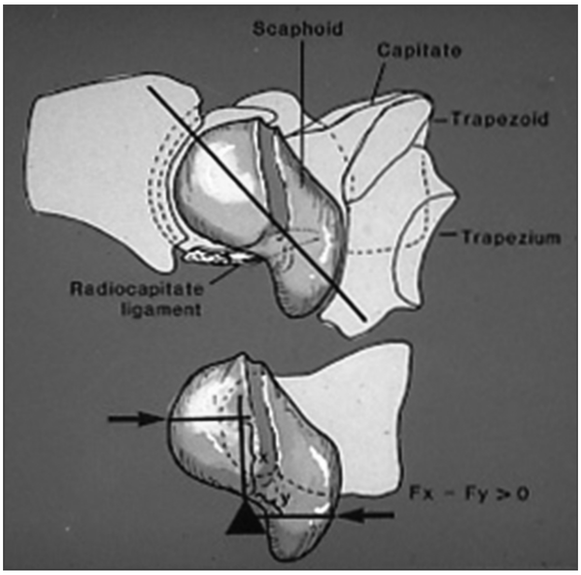

Fig. 2. Because of force coupling on the scaphoid, the scaphoid always flexes under load

In order to more easily explain wrist instabilities, we will set a few ground rules of the normal wrist:

Rule 1: When the wrist is loaded, the scaphoid always wants to flex. The scaphoid lies obliquely (average angle of 47 degrees) to the long axis of the wrist. This obliquity produces force coupling. In other words, the distal force and the proximal force are from opposite directions but not collinear. This force coupling makes the scaphoid flex under load (Fig. 2).

Rule 2: When the wrist is loaded, the lunate wants to extend. The narrower dorsal pole of the lunate, palmar tilt of the lunate fossa, small force coupling, and the paucity of the dorsal capsule are the reasons why the lunate extends under load.

Rule 3: When the wrist is loaded, the triquetrum wants to extend. The spiral articulation with the hamate is responsible for the tendency of the triquetrum to extend under load.

Rule 4: When intercalated segments lose stability and collapse, the segments collapse in a zigzag pattern. Proximal carpal bones are often referred as intercalated segments because there is no motor (muscle tendon unit) attached to them and their movement is controlled by surrounding geometry and restraining structures like ligaments (Fig. 3).

Scapholunate Instability (DISI)

If the SLIL is disrupted, the scaphoid can flex freely [rule 1] and the triquetrum and lunate extend abnormally [rules 2 & 3]. The capitate then flexes relative to the extended lunate following rule 4. This combination of the flexed scaphoid; extended lunate and triquetrum; and flexed capitate is referred as the DISI (dorsal intercalated segment instability) deformity because the lunate – representative of the intercalated segment – is in extension (dorsiflexion) (Fig. 4).

SLIL disruption often results in a gap between the scaphoid and lunate. When this gap is shown in an AP x-ray it is commonly described as the Terry Thomas sign because it resembles a gap between the front teeth of the British comedian.

Lunotriquetral Instability (VISI)

On the other hand, if the LT ligament is disrupted, the scaphoid pulls the lunate into flexion because rule 1 overrules rule 2, while the triquetrum alone goes into an extended position [rule 3]. The capitate extends

Fig. 3. Carpal bones fall in a zigzag pattern when they lose stability just as train cars, which are another example of intercalated segments, do when they have an accident

relative to the flexed lunate following rule 4. This combination of the flexed scaphoid and lunate; extended triquetrum; and extended capitate is referred as the VISI (volar intercalated segment instability) deformity because the lunate – representative of the intercalated segment – is in flexion (volar flexion) (Fig. 5).

Carpal Instability Dissociative (CID)

Dobyns et al. classified wrist instabilities as either carpal instability dissociative (CID) or carpal instability nondissociative (CIND) [20]. Both scapholunate and lunotriquetral instabilities, discussed above, fall into the CID category as disruption of ligaments and thus dissociation between bones is present. Perilunate instabilities, as described by Lichtman et al. also fall into the category of CID [21,22].

Carpal Instability Nondissociative (CIND)

Carpal instability can occur without disruption of either SLIL or LTIL. While the relationship among the proximal carpal bones is unchanged instability can arise between them and the forearm bones or distal carpal bones. These conditions are referred to as CIND [23]. CIND between the two carpal rows include and are sometimes intermixed with the terms midcarpal, capitolunate (CLIP), triquetrohamate or ulnar sided wrist instabilities. CIND between the proximal carpal bones and the forearm bones are also called radiocarpal or translational instability.

Midcarpal instability can be either volar or dorsal. Lichtman et al. described volar sag of the midcarpal joint in patients who experienced a painful spontaneous clunk with ulnar deviation and pronation [24]. Radiographs showed a mild VISI deformity. They eventually classified this as palmar mid carpal instability (PMCI) after fluoroscopy failed to identify any proximal row dissociations, instead showing that the proximal row was snapping into extension with ulnar deviation rather than gradually extending. Laxity of the dorsal radiotriquetral ligament and palmar ulnar arcuate ligament may be the cause.

Louis et al. described another midcarpal instability pattern: capitolunate instability pattern (CLIP) [25]. In this dorsal midcarpal instability pattern, fluoroscopy showed dorsal subluxation of the proximal row and dorsal subluxation of the capitate from the lunate. This subluxation appears to involve the space of Poirier, as closure of this space alleviated symptoms.

While others noticed carpal instability as a complication of the malunited distal radius fracture, Taleisnik and Watson described midcarpal instability from malunited distal radius fractures [26]. Rather than being related to the initial injury, this condition is believed to instead be due to the repetitive overload of the midcarpal joint as a result of the reversal of the normal palmar tilt of the distal radius.

Radiocarpal instability is usually associated with rheumatoid arthritis where ulnar translocation of the carpus occurs, while dorsal or volar instability may occur following a Barton's fracture to the distal radius.

Another example of CIND is rotary subluxation of the scaphoid associated with Kienböck's disease. As the lunate collapses in Kienböck's disease, the capitate migrates proximally forcing the scaphoid to flex abnormally [27]. Elongation of the lunate in the radioulnar direction also promotes flexion of the scaphoid without any ligamentous disruption.

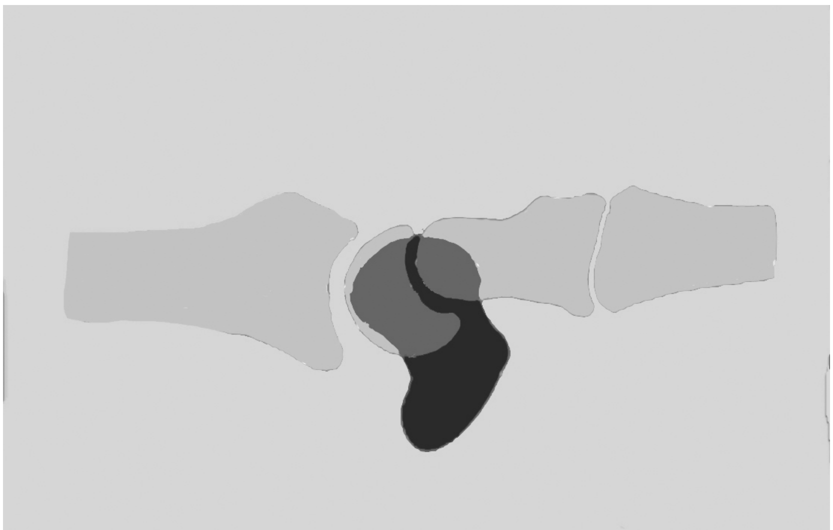

Fig. 4. In DISI, which accompanies scapholunate instability, the scaphoid flexes, the lunate and triquetrum extend, and capitate flexes

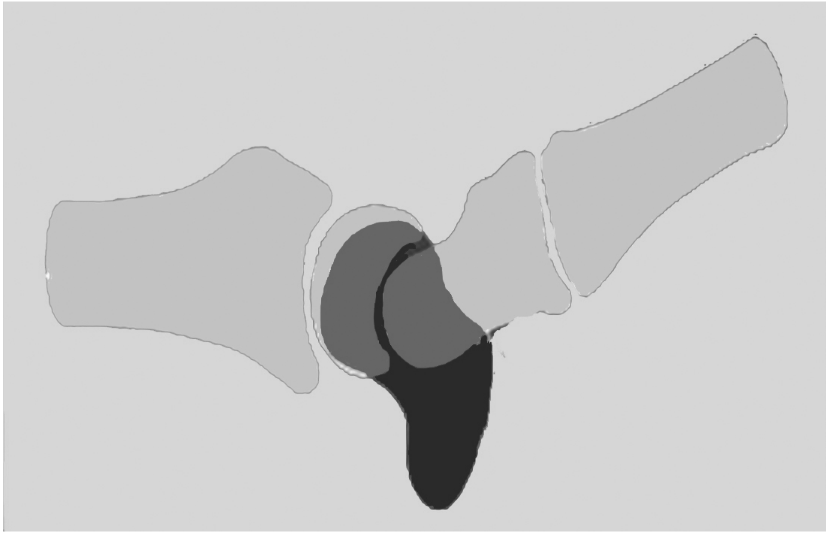

Fig. 5. In VISI, which accompanies lunotriquetral instability, the scaphoid and lunate flex, the triquetrum extends, and the capitate flexes

Carpal Instability Combined or Complex (CIC)

When the wrist sustains an injury with both CID and CIND components, the wrist instability can be classified as CIC. Many CIDs become CICs when the forces are great enough to extend the damage beyond the interosseous ligaments. For example, scapholunate or lunotriquetral instability alone is not CIC. But, if the injury force is great enough to have an additional component such as perilunate dislocation, it becomes a CIC.

Longitudinal (columnar or axial) Carpal Instability

When a traumatic injury to the wrist consists of transarticular and/or transosseous longitudinal disruption of the metacarpal and carpal transverse arches with partial or complete loss of the carpal alignment, longitudinal or axial instability can occur. This includes longitudinal carpal dislocations such as peri-trapezoid, peri-trapezium, and peri-hamate; and longitudinal carpal fracture dislocations such as trans-trapezium, trans-hamate, and trans-triquetrum. Most of the longitudinal instabilities are CICs and unstable because they seldom are subluxation only.

Dynamic vs. Static Carpal Instability

These confusing terms exist mainly for scapholunate instability. Some, including the authors, believe the term static instability is contradictory in itself as an instability is always dynamic. Nonetheless, dynamic instability is defined as a malalignment shown only by stress provocation – either by an examiner or by an x-ray made during or after stressing the wrist while regular x-rays are normal, and this condition does exist. The typical test for dynamic scapholunate instability is the Watson shift test. We often find lax or partially torn SL interosseous ligament during arthroscopic examination in patients with dynamic SL instability.

Treatment of Carpal Instability

Treatment of the wrist instabilities is not discussed in this article. We would, however, like to emphasize that the treatment plan needs to be customized for each patient. Fully understanding each patient's functional problems and functional needs is paramount for appropriate treatment. Hand surgeons must first identify the amount of motion each patient needs. Secondly, it must be determined whether there is a treatment method that will provide this needed motion. Lastly, the surgeon must decide whether this method will provide satisfactory stability. If the above mentioned criteria are not met, the treatment method may not be ideal, and the decision making process must be restarted.

While varied numbers have been proposed, the authors believe 40 degrees each of extension and flexion, 10 degrees of radial and 30 degrees of ulnar deviation are good guidelines for functional range of motion of the wrist for activities of daily living [28].

Terminology of Carpal Instability

Terminology in wrist instability is very redundant and confusing at best. The authors would like recommend readers to refer to the work of IWIW Terminology Committee directed by Dr. Gilula and Dr. Dobyns [29].

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