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Author's Contribution
A – Study Design
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The anatomy and pathophysiology of the wrist

Key words: *wrist pathophysiology, wrist anatomy*

SUMMARY

A basic knowledge of the anatomy and the interrelationships of the structures that make up the joint is a prerequisite for understanding the pathomechanics of the wrist. In the paper, the anatomy (especially including carpal ligaments) and the mechanics of wrist movements, also under load, are described. The features of the common wrist disorders that occur as a result of injury are also explained.

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BACKGROUND

A stable, mobile and pain-free wrist is the key to satisfactory hand function. A basic knowledge of the anatomy and the interrelationships of the structures that make up the joint is a prerequisite for understanding the pathomechanics of the wrist.

The term „wrist" refers to the region connecting the hand to the distal forearm. From a functional point of view the radiocarpal and intercarpal joints form parts of the same mechanism and will be considered together here. The combination of joints is acted on by the same muscles to allow motion in three planes. Mobility requires the simultaneous and interdependent movement of individual components and this complex mechanism is easily disrupted by injury, leading to carpal dysfunction.

ANATOMY

The following points will be helpful in understanding carpal function and its disorders:

- The distal radius, the triangular fibrocartilage complex (TFCC) and the underlying head of the ulna provide a firm base for radiocarpal motion. The scaphoid facet on the distal radius is elliptical and the facet for the lunate is spheroidal.
- The trapezium, trapezoid, capitate and hamate form the distal carpal row. They are effectively a single unit since they are bound together by strong interosseous ligaments, allowing very little movement between them. This unit provides a stable base for the metacarpals.
- The proximal carpal row, consisting of the scaphoid, lunate and triquetrum lies between the platform of the distal radius and TFCC and the distal carpal row. Unlike these relatively rigid structures, the bones of the proximal carpal row (known as the „intercalated segment") change position relative to each other when the hand moves relative to the forearm. It is important to note that the proximal carpal row has no muscles attached to it and the adaptive movement of the bones in the proximal row, which is essential for function of the wrist, depends on the integrity of the ligaments attached to them, or crossing over them, as well as the shapes of the bones and their articular surfaces.

CARPAL LIGAMENTS

he ligaments of the carpus can be divided into intrinsic and extrinsic.

Intrinsic ligaments lie between the bones of the same carpal row. The ligaments of the proximal row are the scapholunate ligament (SLL) and the lunotriquetral ligament (LTL). These ligaments can each be divided into dorsal, proximal and palmar regions. In the SLL the dorsal region is thick and strong, whereas in the LTL the palmar region is the strongest [1,2]. Stout intercarpal ligaments between adjacent bones bind the trapezium, trapezoid, capitate and hamate into a relatively immobile unit.

Extrinsic ligaments cross carpal rows. The palmar ligaments are stronger than the dorsal ligaments. Many different descriptions of the extrinsic ligaments have been given, since they are no more than thickenings of the ligamentous tissue around the carpus and are not particularly well defined. There are currently thought to be three important palmar extrinsic ligaments [3]. The radioscaphocapitate ligament is attached to the radius and the capitate. It crosses the scaphoid and provides a fulcrum around which the scaphoid can rotate. The other important palmar ligaments are the long and short radiolunate ligaments (Figure 1). There are two major dorsal ligaments (Figure 2) [4]. The dorsal radiocarpal ligament extends from the distal radius to attach to the lunate, the lunotriquetral ligament and the dorsal tuberosity of the triquetrum. The dorsal intercarpal ligament extends from the triquetrum to insert into the lunate, the scaphoid and the trapezium.

Fig. 1. The main palmar extrinsic ligaments. RSC: radioscapholunate ligament. LRL: long radiolunate ligament. SRL: short radiolunate ligament

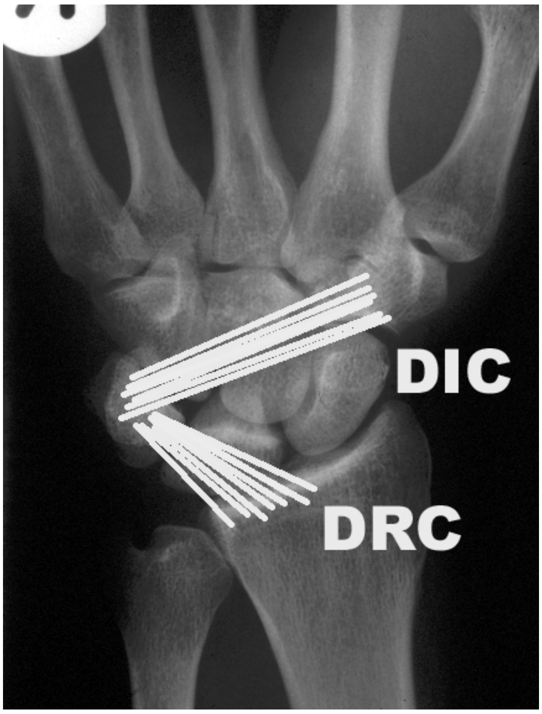

Fig. 2. The main dorsal extrinsic ligaments. DRC: dorsal radiocarpal ligament. DIC: dorsal intercarpal ligament

WRIST MOVEMENTS

The movements of the wrist are flexion, extension, radial and ulnar deviation, and circumduction, which combines the other movements. As has been noted earlier, these movements involve both the radiocarpal joint and the carpus.

FLEXION AND EXTENSION

Approximately half of the ranges of these movements take place at the radiocarpal joint and half at the midcarpal joint between the two rows of the carpus [5]. The bones also shift relative to each other, as can be demonstrated by drawing the long axes of the bones on lateral radiographs (Figure 3).

RADIAL AND ULNAR DEVIATION

In radial deviation the trapezium approaches the radial styloid. To allow this to happen the scaphoid assumes a more horizontal position, sliding smoothly within its elliptical fossa at the distal end of the radius (Figure 4). In the normal wrist the lunate follows the scaphoid into flexion. These movements depend on the integrity of the carpal ligaments, most notably the SLL.

In ulnar deviation a dorsal translation of the capitate on the lunate causes the lunate to extend along with the attached scaphoid, which appears relatively much longer on radiographs (Figure 4).

In both movements the triquetrum passively follows the movements of the scaphoid and lunate, although the degree of flexion or extension of the triquetrum is less than that of the scaphoid [6].

THE WRIST UNDER LOAD

When a force is applied across the wrist, for example when gripping an object, a torque or twisting moment is applied to the proximal row but the bones stay in position relative to each other provided their

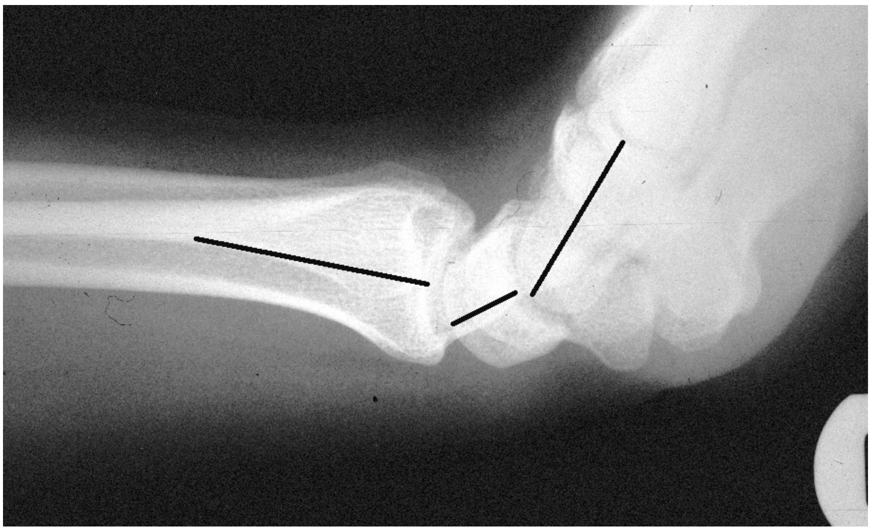

Fig. 3a. The wrist in extension showing that the movement occurs at both the radiocarpal and midcarpal joints. Note that the axes of the bones also shift relative to each other. b. The wrist in flexion

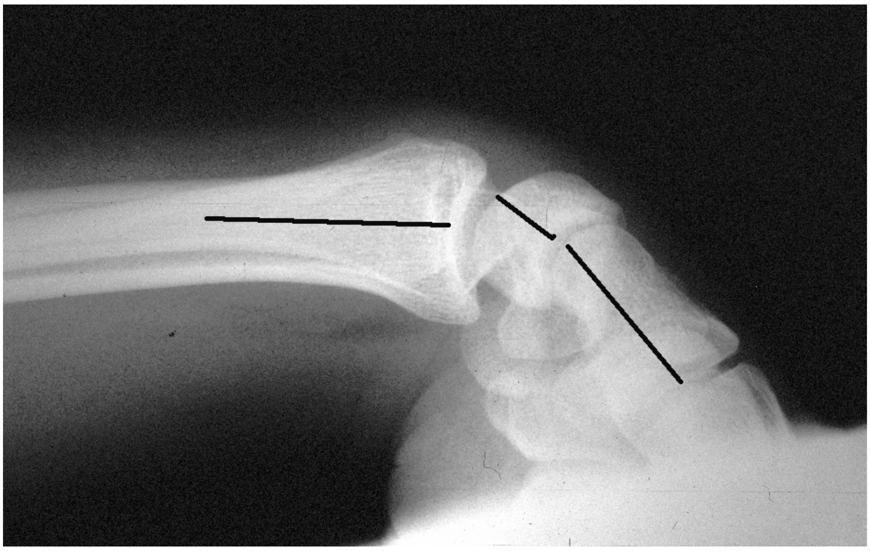

Fig. 3b. The wrist in flexion

Fig. 4. The wrist in ulnar (left) and radial (right) deviation. The change in position of the scaphoid is well seen. Note also the shift in position of the scaphoid and lunate relative to the distal radius

ligamentous connections are intact. If the bones were not constrained by their ligamentous attachments the scaphoid would be forced into flexion. The shape of the articulation between the hamate and triquetrum would tend to push the triquetrum into extension. In the normal carpus the extending force acting on the triquetrum is counterbalanced by the intact SLL and LTL which transmit a flexing moment to the triquetrum via the lunate (Figure 5).

PATHOPHYSIOLOGY OF THE WRIST

This simple introduction to the anatomy and functional aspects of the articulations that make up the wrist allows an explanation of the features of the common wrist disorders that occur as a result of injury. Thus it can be readily appreciated that when the SLL is ruptured the scaphoid will assume a horizontal, or flexed, position under load [7]. The forces acting on the lunate and triquetrum, which are still attached to each other by the LTL, will move them into extension. When the LTL is ruptured but the SLL is intact the scaphoid and lunate will move into flexion together and the triquetrum will extend.

Likewise the long-term changes that occur after injury can be explained. Rupture of the SLL means that the movements of the scaphoid in its elliptical fossa at the distal end of the radius are uncontrolled and incongruent, eventually leading to the characteristic pattern of osteoarthritis between the scaphoid

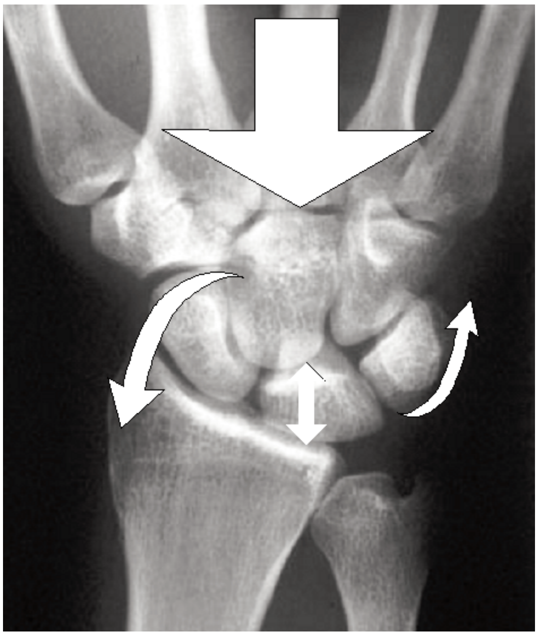

Fig. 5. When force is transmitted through the carpus there is a tendency for the scaphoid to be pushed into flexion and for the triquetrum to extend. The intact carpal ligaments prevent these movements occurring in the normal wrist

and distal radius that is seen in the wrist with scapholunate advanced collapse (SLAC wrist) [8]. In contrast the lunate sits in a spheroidal fossa and despite its lack of attachment to the scaphoid there is no incongruency between the lunate and its fossa when the lunate moves and hence osteoarthritis does not occur.

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