Anatomy of the wrist and distal radioulnar joint

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EFORT Congress, June 3\textsuperscript{rd}, 2009, Vienna (Austria)
Wrist joints

- Distal radioulnar
- Radiocarpal
- Midcarpal
  - Lateral part: scaphotrapeziotrapezoid STT
  - Medial: 4 bones or 4 corners
- Carpometacarpal
  - 1st or trapeziometacarpal
  - 2nd to 4th fingers
  - 5th finger
RA is a synovial disease, OA no

- 3 synovial joints, theoretically independent one from another:
  - Distal radioulnar joint
  - Radiocarpal joint
  - Midcarpal joint

- Transverse separations:
  - DRU articular disk
  - Scapholunate and triquetrolunate intersosseous ligaments
RA is a synovial disease

- RA can initially involve 1, 2 or 3 of them
RA is a synovial disease

• With time, the transverse ligaments, which isolate each joint from the other ones, weaken, perforate and disappear
  – DRUJ articular disk
  – Scapholunate ligament
  – Triquetrolunate ligament
  – Sometimes bones too!
RA is a synovial disease

- Bony erosions are located at the points of insertion of the synovial membrane
- Synovitis weakens all the ligaments, specially the thinnest ones
Distal radioulnar joint

- Cylindrical joint
- Ulnar notch of radius
- Head of ulna
- Articular disc
- Anterior and posterior radioulnar lig.
TFCC = Triangular Fibro-Cartilaginous Complex

- DRU articular disc or ligament of ulnar head
- Volar and dorsal DRU ligaments
- Ulnocarpal ligaments
- ECU sheath
DRU articular disc

- Fibrocartilage inserted on
  - Base of ulnar styloid process
  - Edge between carpal and ulnar articular surfaces of distal radius
Volar and dorsal DRU ligaments

- Lateral insertion on the volar and dorsal borders of ulnar notch of radius
- Medial insertion on ulnar head
- Distal insertion on broad peripheral border of DRU articular disc
Extensor carpi ulnaris sheath

- 2 lamina
  - Deep proper sheath, adhering to dorsal border or DRU articular disc and dorsal DRU ligament
  - Extensor retinaculum
Radiocarpal joint

- **Ellipsoid**
  - 2 degrees of freedom

- **Carpal surface of radius and DRUJ disc**

- **Carpal condyle**
  - Scaphoid
  - Lunate
  - Triquetrum
Midcarpal joint

• Lateral part: scaphotrapezio trapezoid STT
• Medial:
  – 4 bones or 4 corners
  – Ellipsoid
Pisiform bone

- In front of triquetrum
- Does not take part in the carpal condyle
- Does not move with the 7 other carpal bones
- Projects forward and increase FCU level arm
- Gives insertion to ADM
- Connected with hamulus of hamate and 5th metacarpal by ligaments
Articulation of pisiform bone

• Plane joint between posterior aspect of pisiform and anterior aspect of triquetrum
• Possible communication with ulnar recess of radiocarpal joint
• Moved
  – Proximally by ECU (limited displacement by distal ligaments)
  – Distally by ADM
Carpometacarpal joints

- **1\textsuperscript{st} or trapeziometacarpal** for thumb opposition
- **2\textsuperscript{nd} to 4\textsuperscript{th} fingers**
  - Distal row bones connected to bases of metacarpal bones (especially 2\textsuperscript{nd} et 3\textsuperscript{rd})
  - 2\textsuperscript{nd} et 3\textsuperscript{rd} metacarpals are quite but not really immobile
- **5\textsuperscript{th} finger for opposition of 5\textsuperscript{th} finger**
Means of union

- Capsular ligaments reinforcing capsule, joining mainly bones which do not belong to the same row
  - Anterior or volar capsule
  - Posterior or dorsal capsule
- Interosseous ligaments intraarticular, joining bones of the same row, strong and short (1-2 mm), whose surface is covered by fibrocartilage, in continuity with adjacent bone cartilage
- Distant ligaments: flexor retinaculum +/- extensor retinaculum
Scapholunate interosseous ligament

- Joins the proximal parts of articular surfaces of the scapholunate joint
- Reinforced volarly by the radioscapopholunate lig.
- Connects lunate to scaphoid
  - *Lunate follows scaphoid*
  - *Rupture: dissociation in behavior of both bones*
Scapholunate interosseous ligament

• 3 parts
  – palmar (volar):
    117.9 +/- 21.3 N
  – central (proximal):
    62.7 +/- 32.3 N
  – dorsal (the most important):
    260.3 +/- 118.1 N
Triquetrolunate interosseous ligament

• Joins the proximal parts of articular surfaces of the triquetrolunate joint
• Reinforced volarly by the radiolunate lig.
• Connects lunate to triquetrum
  – *Lunate follows triquetrum*
  – *Rupture: dissociation in behavior of both bones*
Palma radiocarpal and midcarpal ligaments: the 2 volar vertical “V”

- Thickest part of the capsule
- Oblique distally and ulnarily
  - Radioscaphocapitate lig. (2)
  - Short radiolunate lig. (3)
  - Radiolunotriquetral lig. (4)
  - Radioscapholunate lig.
Radioscapholunate ligament

- **Origin:** volar border of radius, between scaphoid and lunate notches
- **End:** proximal pole of scaphoid, scapholunate interosseous ligament, lunate
- **Vertical and deep to radiolunotriquetral ligament**
- **Made of connective tissue covered by synovium (Poirier’s fold) containing the end of the anterior interosseous vascular bundle**
Radioscapholunate ligament

- Responsible for
  - The osseous cyst in the distal radius in front of the scapholunate ligament
  - The rupture of the scapholunate ligament (Gilula’s arches)
Palma radiocarpal and midcarpal ligaments: the 2 volar vertical “V”

- From the anterior border of radius and DRU articular disk
- To
  - The anterior horn of lunate: proximal volar “V”
  - Body of capitate: distal volar “V”
Dorsal radiocarpal and midcarpal ligaments: the dorsal horizontal “V”

- Dorsal radiocarpal (or radiolunotriquetral) lig.
- Dorsal midcarpal lig.
- +/- dorsal ulnocarpal lig.
Dorsal radiocarpal and midcarpal ligaments: the dorsal horizontal “V”

- All the dorsal ligaments converge toward triquetrum
- Dorsal radiocarpal ligament (dorsal radiolunotriquetral lig.) fights against ulnar translation of carpus
Weakening of the ligaments allows carpal gliding, especially in RA

- Global slope of the carpal surface of radius directed toward
  - Proximally and medially 20-25°
  - Proximally and anteriorly 10-15°

- Spontaneous trend of carpus to glide proximally, ulnarly and volarly
Weakening of the ligaments allows carpal gliding

- Ulnar gliding of carpus means failure of ligaments oblique ulnarly and distally
  - Theoretically it could be compensated by retightening these ligaments
  - It fights also against radial tilt
  - Only the dorsal ones?
Weakening of the ligaments allows carpal gliding

- Volar gliding of carpus means failure of both the dorsal and volar ligaments
  - It cannot be compensated by retightening dorsal capsule
  - It needs a stabilizing procedure (radiolunate arthrodesis, for ex.)
Medial and volar gliding of carpus
Weakening of the dorsal (and volar) ligaments allows carpal pronation

• No other procedure than an arthrodesis is able to stabilize the wrist in the transverse plane
Dorsal ulnar head dislocation

- Weakening of the DRU stabilizers leads to dorsal ulnar head dislocation (or palmar dislocation of the distal radius)
- These stabilizers form the TFCC
DRUJ stabilization

- Theoretically, DRUJ stabilization needs
  - Reconstruction or palliation of ligaments
  - Preservation of articular disk (at least peripheral part)
  - Reconstruction of ECU sheath (major point in dorsal approaches)
6 dorsal compartments with their own synovial sheath

- 1: Abductor pollicis longus (APL) and extensor pollicis brevis (EPB)
- 2: Extensor carpi radiales longus et brevis (ECRL & ECRB)
- 3: Extensor pollicis longus (EPL)
- 4: Extensor digitorum (ED) and extensor indicis proprius (EIP)
- 5: Extensor digiti minimi (EDM)
- 6: Extensor carpi ulnaris (ECU)
Tendons on the dorsal aspect of the wrist

- The more exposed to rupture are:
  - Extensor pollicis longus, that reflects onto the dorsal tubercle of radius
  - Extensor digiti minimi, in case of dorsal dislocation of ulnar head
Extensor tendon ruptures

• Dorsal dislocation of ulnar head, irregular because of DRU synovitis
• EDQ rupture
Extensor digiti minimi EDM

- Its rupture can be entirely hidden by the extensor communis tendon to the little finger (when present 70%)
- Its rupture is immediately visible when the EDM is the only extensor tendon to the little finger and there is only a weak junctura tendinorum from the extensor communis tendon to the ring finger (24%)
Tendon rupture and tenodesis effect

• Most of the tendon repairs act more as tenodesis than as active
• It seems essential to preserve this tenodesis effect through sagittal mobility, especially in case of tendon rupture
Wrist center of rotation

- Center of rotation located at the head of hamate
- That of a prosthesis should be at the same place

Lanoy et al 1982

Wrist movements in the sagittal plane

- Flexion (palmar flexion) 85° according to Kapandji (50° RC + 35° MC), 75° according to Ryu
- Extension (dorsal flexion) 85° according to Kapandji (35° MC + 50° MC), 70° according to Ryu
- *Partial carpal arthrodesis restricts mobility asymmetrically*
Wrist movements in the sagittal plane

• Unequal repartition between both joints: Part of radiocarpal joint in flexion
  – 60% according to Kapandji (50 out of 85°),
  – 50% according to Viegas et al 1997, Patterson et al 1998
  – 40% according to Sun et al 2000

• Unequal repartition between the 3 columns (Werner et al 1997)
  – 90% in the lateral column between scaphoid and radius
  – 65% in the medial column between radius and triquetrum
Wrist movements in the frontal plane

- Abduction (radial tilt) 25° according to Kapandji (15° RC + 10° MC), 20° according to Ryu
- Adduction (ulnar tilt) 45° according to Kapandji (20° RC + 25° MC), 40° according to Ryu

*Partial carpal arthrodesis restricts mobility asymmetrically*
Global wrist movements

• Useful mobility (Ryu et al)
  – 80° in the sagittal plane
  – 40° in the frontal plane

• Useful mobility (Brumfield 1984)
  – Cleaning 10°/15°
  – Daily living 5°/35°

• Most important movements occur in an oblique plane
  – From extension and radial tilt
  – To flexion and ulnar tilt
Axes of movements

Fick 1904
Static behavior of carpus in neutral position

- Lunate distal surfaces turned volarly of about the same value than the carpal surface of radius
  - Radiolunate angle 10° (from +15° to −20°)
  - Capitolunate angle 10°
- Scaphoid belongs to both rows and bisects between horizontal and vertical lines
  - Scapholunate angle 55° (from 30° to 70°)
Static behavior of carpus

- Lunate is connected to scaphoid and triquetrum by two interosseous ligaments
- Scapholunate ligament prevents lunate from isolated extension
  - *Extension of lunate (DISI) is a sign of scapholunate ligament rupture*
- Triquetrolunate ligament prevents lunate from isolated flexion
  - *Extension of lunate and scaphoid (VISI) is a sign of triquetrolunate ligament rupture*
Dynamic behavior of carpus in flexion

- Flexion of the proximal row
  - Scaphoid becomes horizontal (ring sign)
  - Lunate distal articular surface turns more volarly
- Flexion of the distal row
Dynamic behavior of carpus in extension

• Extension of the proximal row
  – Scaphoid becomes vertical
  – Lunate distal articular surface turns dorsally

• Extension of the distal row
Dynamic behavior of carpus in flexion-extension

Lateral view
Dynamic behavior of carpus in flexion-extension

Medial view
Dynamic behavior of carpus in radial tilt

- Flexion of scaphoid (ring sign)
- Lunate follows scaphoid and turns its distal articular surface volarly
- Triquetrum and capitate come closer
- Hamate and lunate are no more close
Dynamic behavior of carpus in ulnar tilt

- Extension of scaphoid (maximal length)
- Lunate follows scaphoid and turns its distal articular surface dorsally
- Triquetrum and capitate are no more close
- Hamate and lunate come closer
Dynamic behavior of carpus

- The whole carpus changes its spatial arrangement, but keeps a quite identical height.
- Carpal height index (Youm et McMurtry): 0.54 ± 0.03
- In case of destabilization, carpal bones rearrange in order to present the radius the minimal height: carpal collapse.
Dynamic behavior of carpus in radial and ulnar tilts
Motor muscles

Flexion

Ulnar tilt

Extension

Radial tilt
Arm of level
Repartition of strains in the radiocarpal joint

Schuind et al 1995
Repartition of strains in the midcarpal joint

Schuind et al. 1995
Wrist prosthesis

• Radial implant in a single bone
• Carpal implant in a bag of bones
  – Better total wrist indication: carpitis with a one-bone carpus
  – One should theoretically fuse the remaining carpal bones (but it is difficult)
Wrist prosthesis
Neither stem nor screw should cross the carpometacarpal joint, or fuse it.