Anatomy and Kinesiology of the Wrist: *Reviewing the Essentials*

Presented by:
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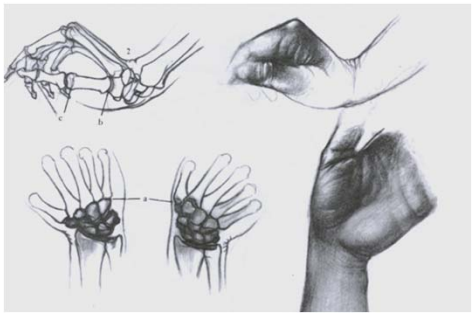
Marquette University



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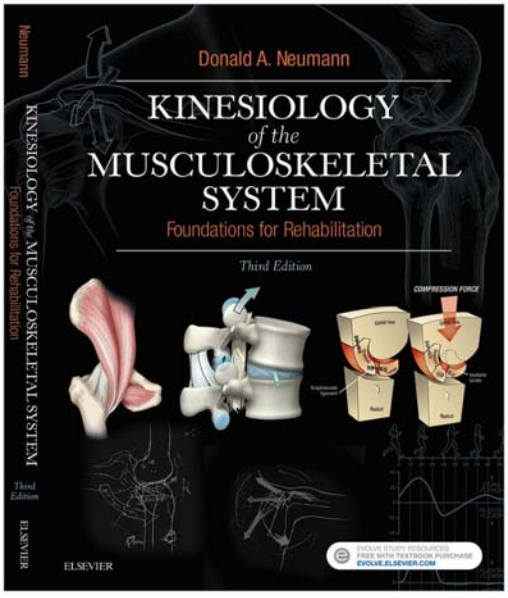


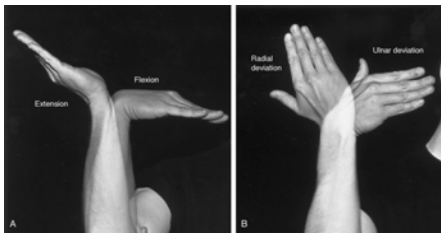
Complete citations of all references cited in this talk can be found in separate Word documents.

Also, refer to entire wrist references used in 2024 (4th) edition

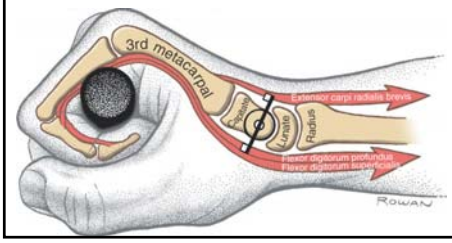
Most artwork and figures from Neumann DA; Kinesiology of the Musculoskeletal System, Elsevier, 2017

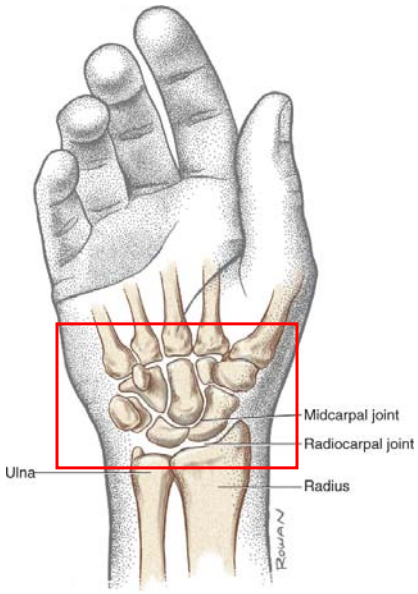
The Wrist:

The functional and structural link between the hand and forearm



Mobility, placement, and stability of hand





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Anatomy and Kinesiology of the Wrist: *Reviewing the Essentials*

Topics:

Brief overview*:* Effective and safe transfer of loads across upper limb: *Two clinical examples*

Extrinsic and Intrinsic ligaments: *Classic Anatomical Organization*

Kinematics of the Wrist: Traditional vs Dart thrower's position

Importance of wrist extensors while making a fist

Selected muscle actions at the wrist

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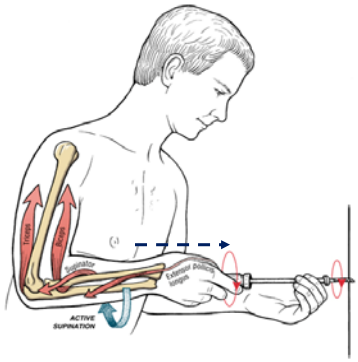
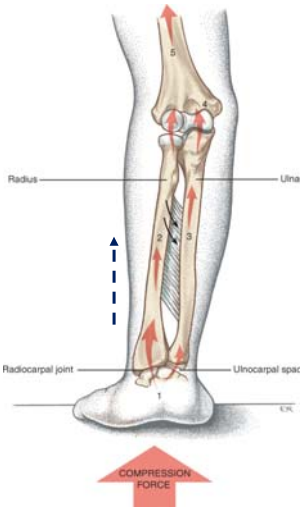
Effective and safe transfer of loads across upper limb: Two clinical examples

Distal transfer of kinetics



Proximal transfer of kinetics



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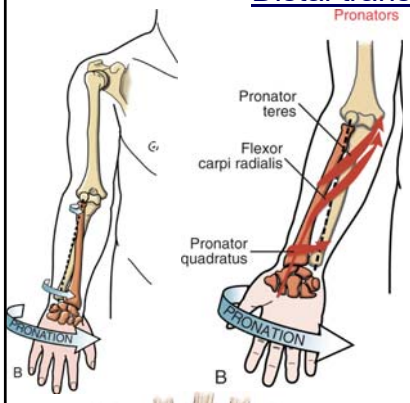
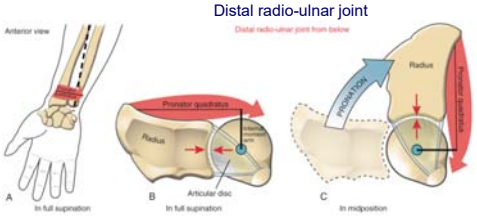
Distal transfer of muscular kinetics

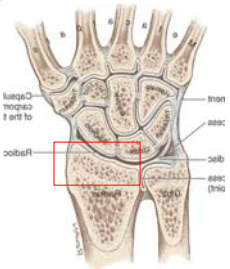
Pronators



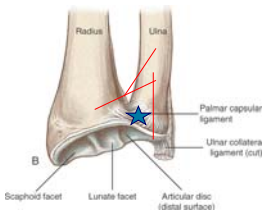
Consider, as an example, resisted pronation

Distal radio-ulnar joint





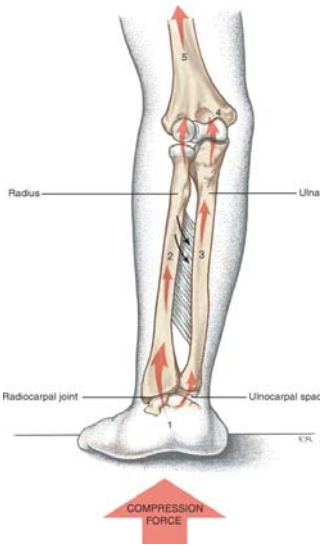
Radiocarpal joint



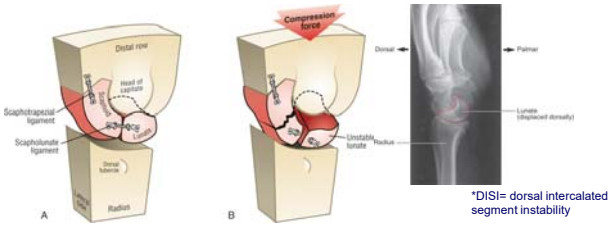
- Triangular fibrocartilage complex
- Pronator quadratus
- Tendon of the extensor carpi ulnaris
- Distal oblique fibers of the interosseous membrane

Neumann 2017

Proximal transfer of gravitational ("reactive") kinetics



Associated scaphoid fx and lunate instability



*DISI= dorsal intercalated segment instability

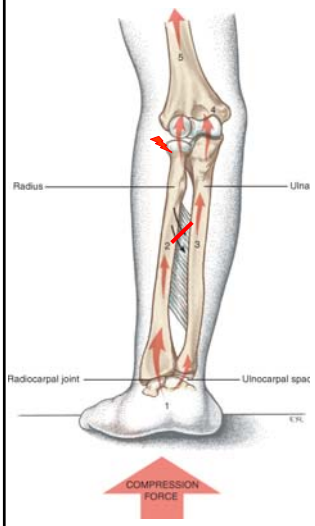
Scapholunate (SL) disassociation

Picha et al 2012

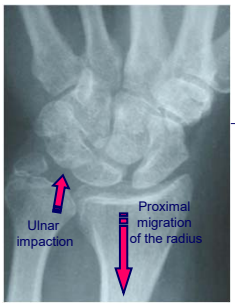
SL advanced collapse

Campbell et al 2020

Also consider tears of the interosseus membrane, fracture (shortening) of the radius or radial head…



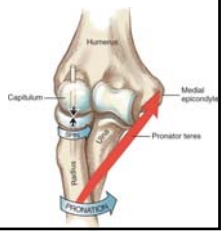
Excessive proximal migration of the radius and associated carpal stress…



Early Kienbock's disease (MRI, low T1 signal intensity)

Brogan et al 2019

Resulting in TFCC injury, Kienbock's disease…



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Ligaments of the Wrist:

Functions:

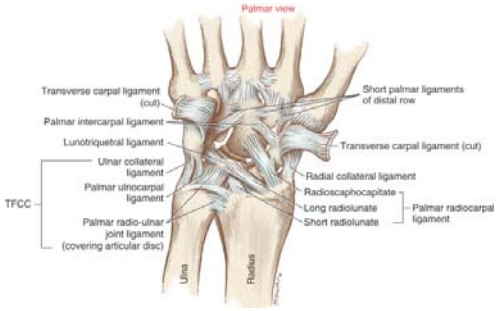
Stabilize the many joints

Transfer forces across carpus

Define (protect) end-ranges of motion

Help drive arthrokinematics

With afferent nerves, provide mechanoreception and proprioception



How many carpal ligaments are there and how are they organized?

at least 30!!

Neumann 2017

Extrinsic and Intrinsic ligaments:

Classic Anatomical Organization

Neumann, 2017
Gray's Anatomy, 2021
Taleisnik,1985

BOX 7.1 Extrinsic and Intrinsic Ligaments

EXTRINSIC LIGAMENTS OF THE WRIST

Dorsal radiocarpal
Radial collateral
Palmar radiocarpal
- Radioscaphocapitate
- Radiolunate (long and short)

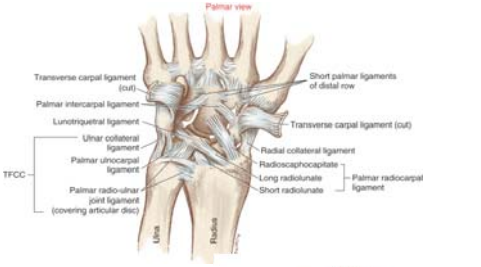
Triangular fibrocartilage complex (TFCC)
- Articular disc (triangular fibrocartilage)
- Distal radio-ulnar joint capsular ligaments
- Palmar ulnocarpal ligament
  - Ulnotriquetral
  - Ulnolunate
- Ulnar collateral ligament
- Fascial sheath that encloses the tendon of the extensor carpi ulnaris

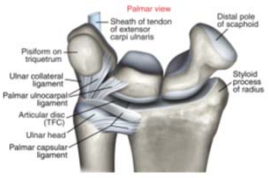
INTRINSIC LIGAMENTS OF THE WRIST

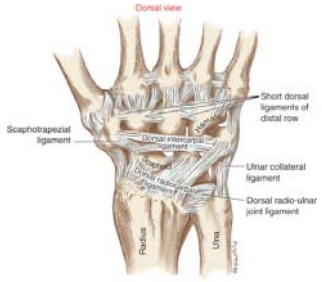
Short (distal row)
- Dorsal
- Palmar
- Interosseous

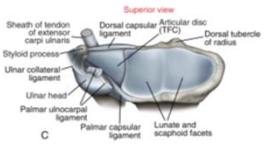
Intermediate
- Lunotriquetral
- Scapholunate
- Scaphotrapezial and scaphotrapezoidal

Long
- Palmar intercarpal ("inverted V")
  - Lateral leg (capitate to scaphoid)
  - Medial leg (capitate to triquetrum)
- Dorsal intercarpal (trapezium-scaphoid-lunate-triquetrum)









Neumann 2017

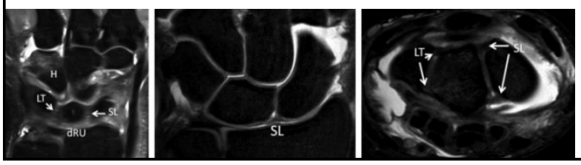
Extrinsic and Intrinsic ligaments:

Clinical or surgical-based organization…

Shahabpour et al 2021 (Belgium)

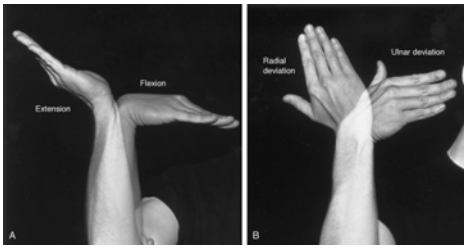
Table 1 Carpal ligaments (including extrinsic, midcarpal and intrinsic ligaments)

Scapholunate ligament complex ←
- Intrinsic scapholunate (SL) ligament
- Extrinsic palmar radiocarpal: radioscaphocapitate (RSC), long radiolunate (LRL), short radiolunate (SRL) ligaments
- Extrinsic dorsal radiocarpal (DRC) or radiotriquetral (DRT) ligament
- Dorsal intercarpal (DIC): dorsal triquetroscaphoid (DTS) and triquetrotrapezoidotrapezial (TTT) ligaments
- Dorsal capsular scapholunate septum (DCSS)
- Intrinsic palmar midcarpal scaphotrapeziotrapezoid (STT) ligament complex: intrinsic palmar scaphotrapezial (STz), scaphocapitate (SC) and capitotrapezial (CTz) ligaments
Palmar midcarpal ligaments ←
- Intra-articular midcarpal (distal) part of the extrinsic RSC ligament
- Intrinsic triquetrohamatocapitate (THC), scaphocapitate (SC), and palmar triquetroscaphoid (PTS) ligaments
Ulnar-sided ligaments (lunotriquetral ligament complex) ←
- Intrinsic lunotriquetral (LT) ligament
- Extrinsic palmar ulnotriquetral (pUT), ulnolunate (UL), and ulnocapitate (UC) ligaments
- Extrinsic dorsal ulnotriquetral (dUT) ligament and the triquetral attachment of the extrinsic DRT ligament and of the midcarpal DIC ligament
- Extrinsic palmar LRL ligament and the midcarpal PTS and THC ligaments



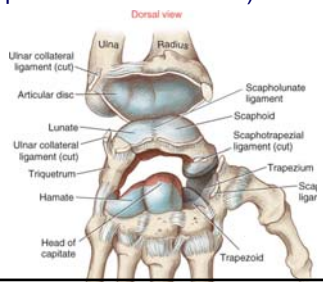
…Others:
Brogan et al, 2019
Garcia-Elias et al, 2017
Hagert et al, 2016

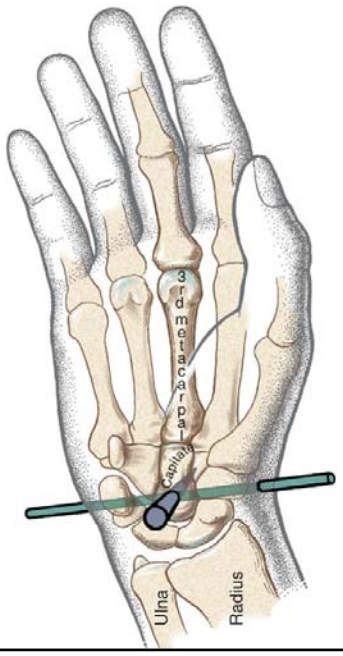
Osteokinematics



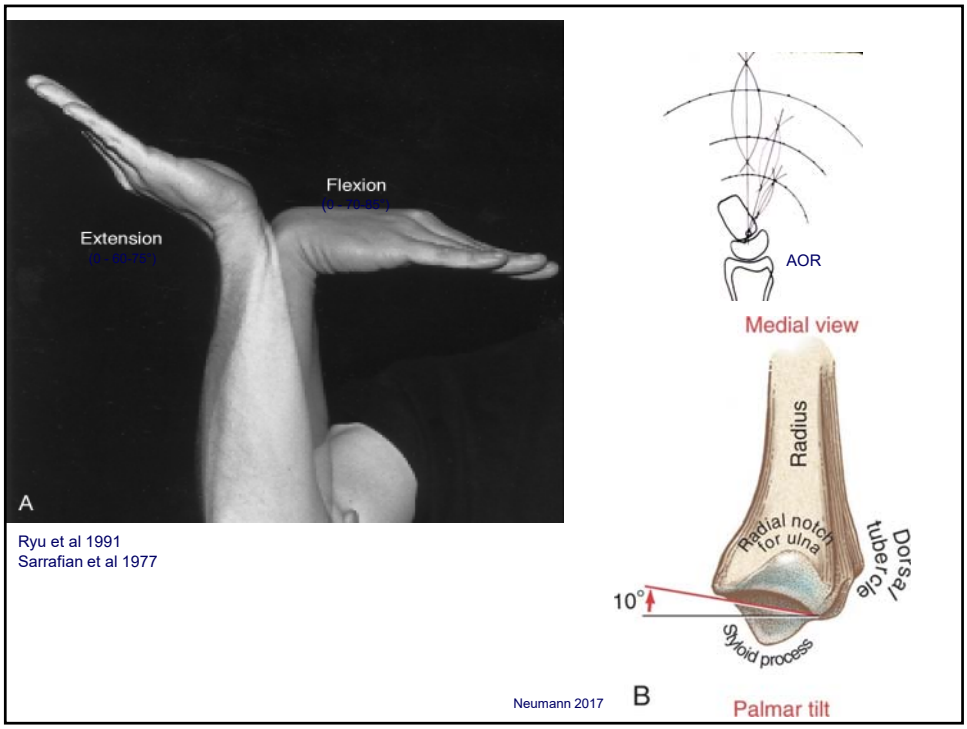
Two degrees of freedom..
What "limits" the third degree (axial rotation)?

…34 degrees of total passive axial rotation allowed at wrist (Gupta and Moosawi 2005)



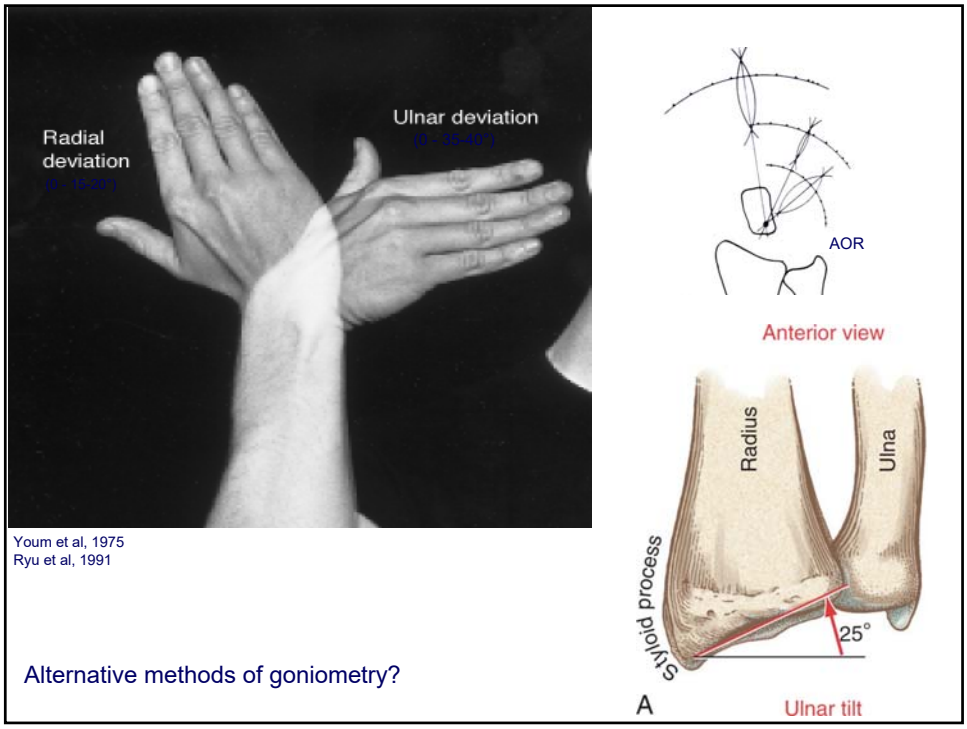


Neumann 2017



Ryu et al 1991
Sarrafian et al 1977

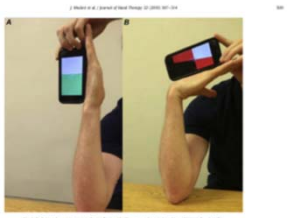
Neumann 2017

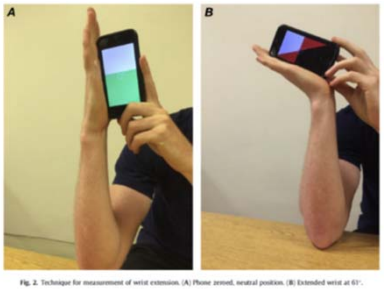


Youm et al, 1975
Ryu et al, 1991

Alternative methods of goniometry?

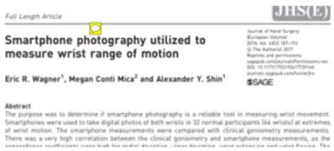
ROM via Smartphone features





Modest J, Clair B, DeMasi R, et al:
Self-Measured wrist range of motion by wrist-injured and wrist-healthy study participants using a built-in Iphone feature as compared with a universal goniometer. *J Hand Ther* 32(4):507-514, 2019.

ROM via Smartphone photography



Smartphone photography utilized to measure wrist range of motion

Eric R. Wagner[1], Megan Conti Mica[2] and Alexander Y. Shin[1]

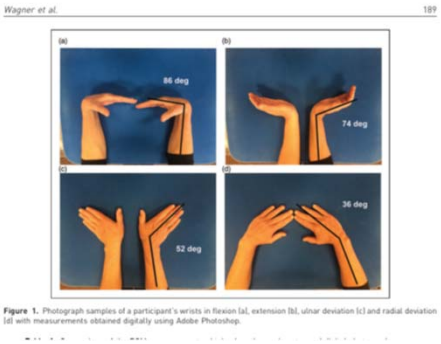
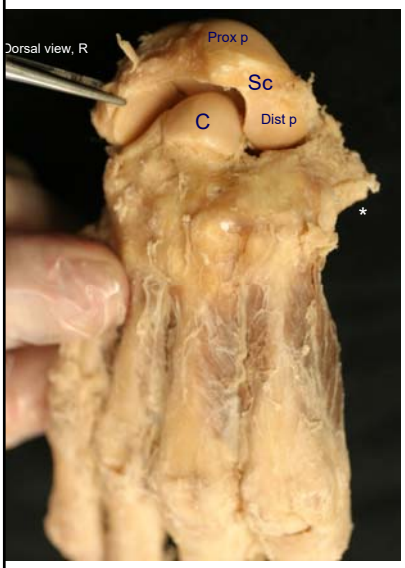


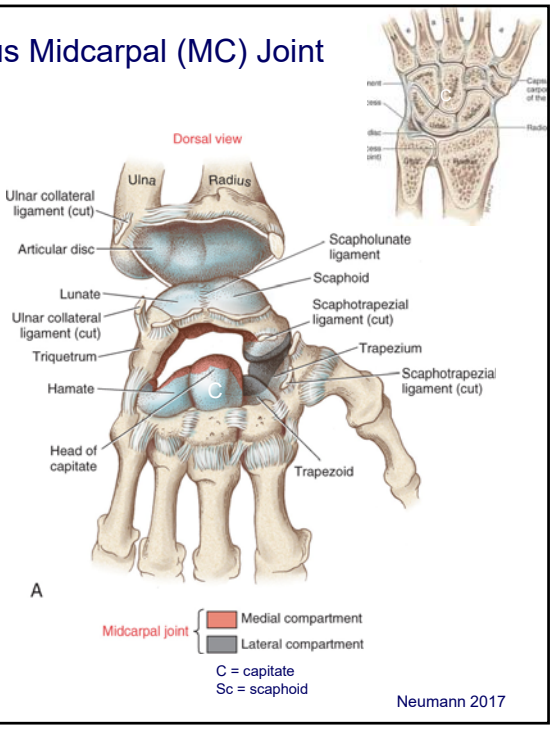
Figure 1. Photograph samples of a participant's wrists in flexion [a], extension [b], ulnar deviation [c] and radial deviation [d] with measurements obtained digitally using Adobe Photoshop.

Wagner ER, Conti Mica M, and Shin AY:
Smartphone photography utilized to measure wrist range of motion. *Journal of Hand Surgery: European Volume* 43(2):187-192, 2018.

Radiocarpal (RC) versus Midcarpal (MC) Joint



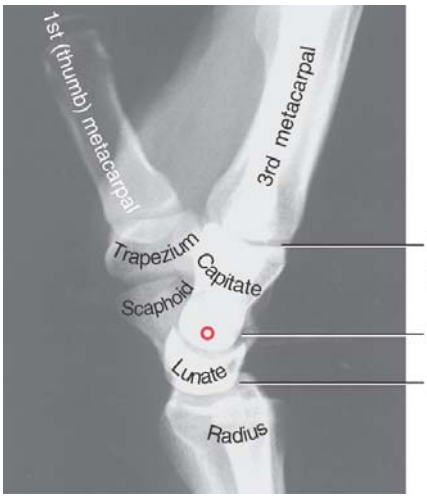
* first metacarpal removed



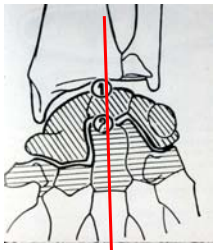
C = capitate
Sc = scaphoid

Neumann 2017

One method to visualize arthrokinematics: "Central Column" Model: radius-lunate-capitate-3rd MC

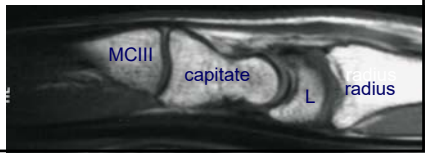


Rainbow et al 2016



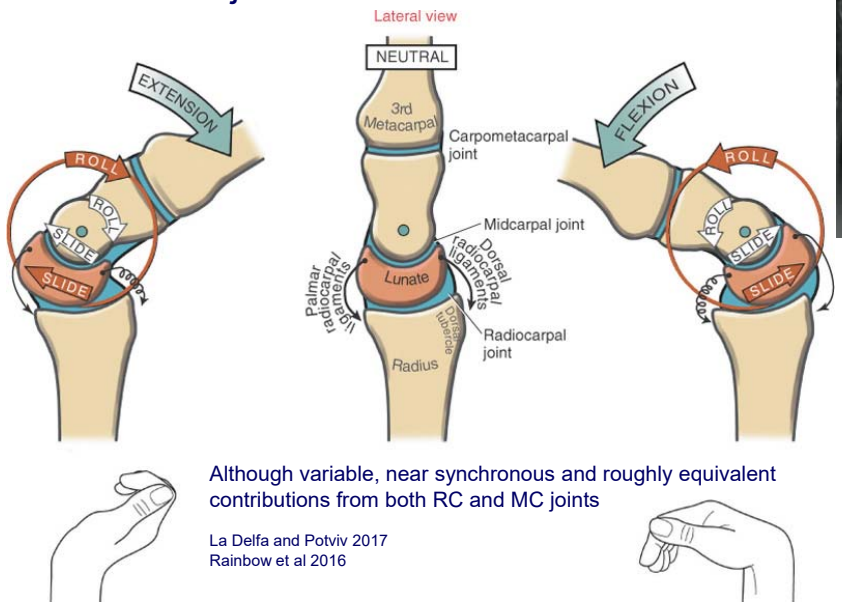
1= RC joint
2= MC joint

…Useful clinical utility
(Sekiguchi et al 2024)



Neumann 2017

Dynamic interaction within the joints of the central column

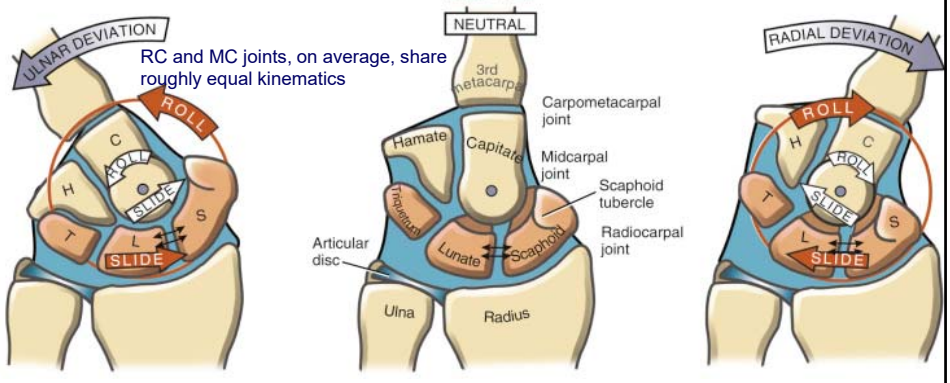


Although variable, near synchronous and roughly equivalent contributions from both RC and MC joints

La Delfa and Potviv 2017
Rainbow et al 2016

Neumann 2017

Frontal plane dynamic interaction within the wrist



RC and MC joints, on average, share roughly equal kinematics

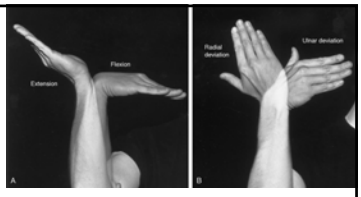
La Delpa et al 2017
Kaufman et al 2005
Bain et al 2025

What segments dominate?

Neumann 2017
Werner 2016

"Dart thrower's" motion (DTM)

Extension with rad. dev.
Flexion with ulnar dev.

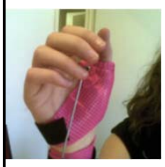


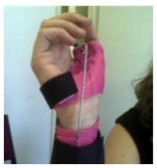
uniquely human (hammering, drinking, etc)

reflects actions of many wrist muscles

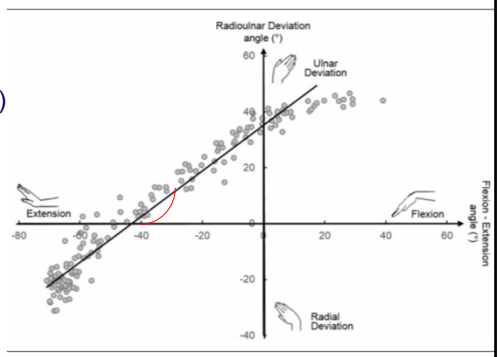
shifts the dominance of motion from RC to MC joint: (may protect scapho-lunate ligament)

DTM-limiting orthosis





Anderson et al 2016

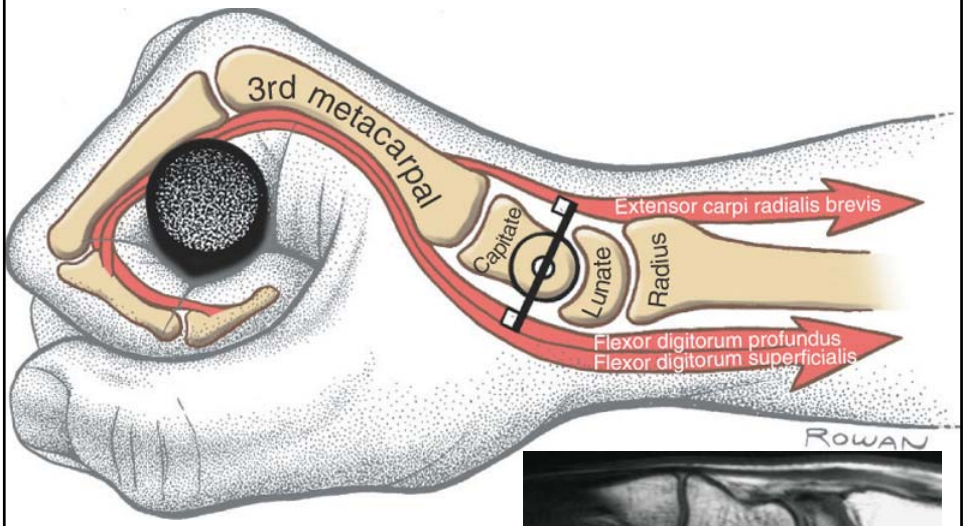


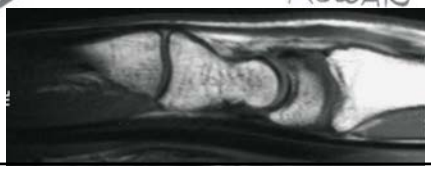
Vardakastani et al 2018

*DTM angled out of sagittal plane by about 25-50° (Moritomo et al 2014)

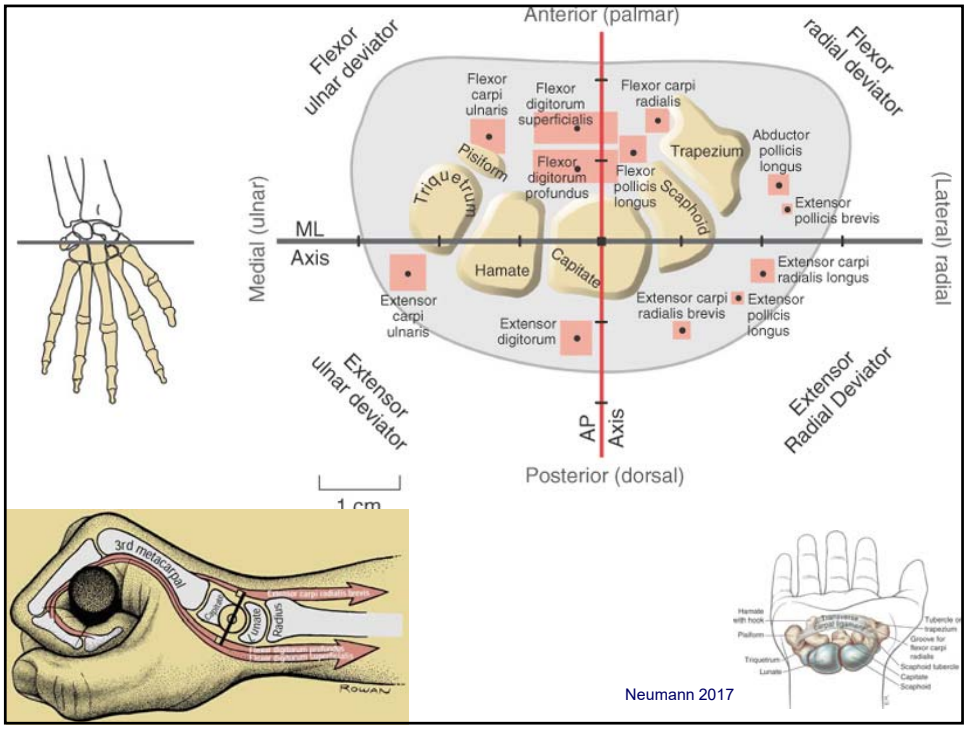
Bergner et al 2020, Werner et al 2016, Moritomo et al 2014

Importance of wrist extensors while making a fist

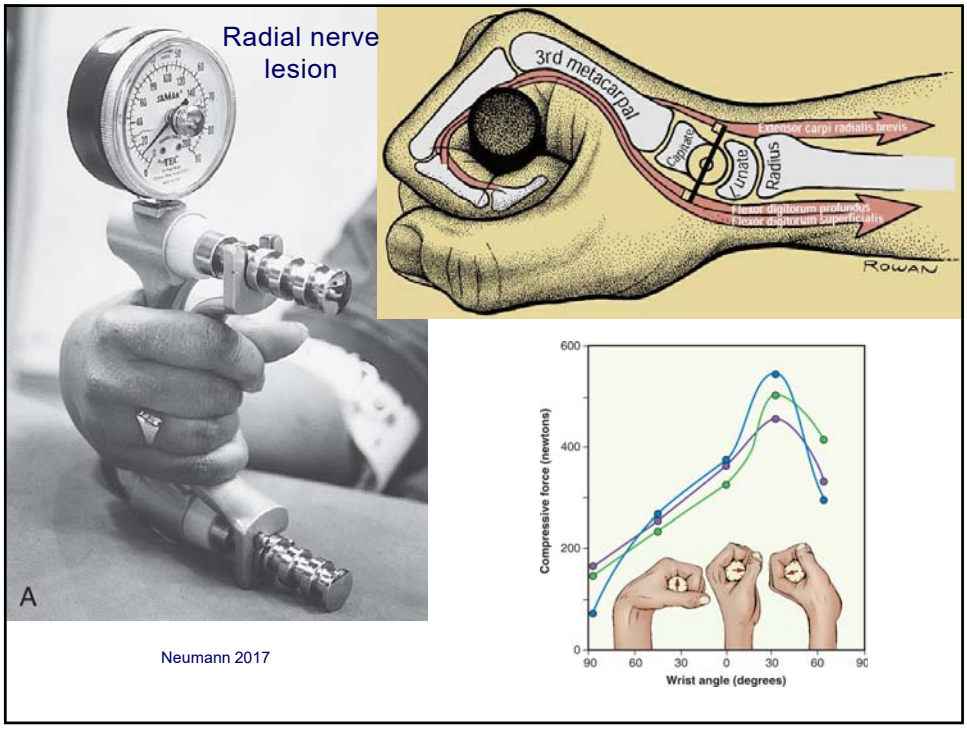




Neumann 2017

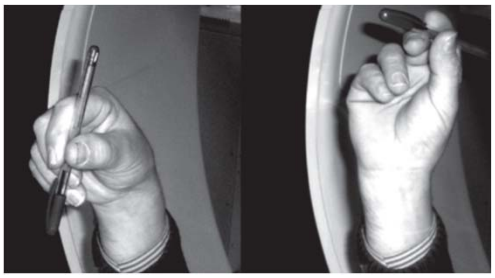


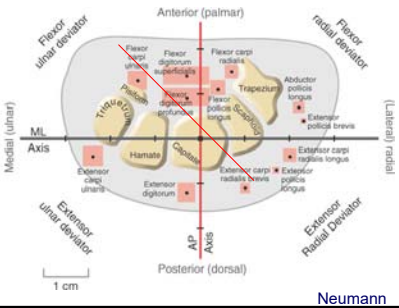
Neumann 2017



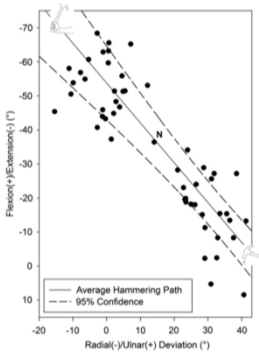
Neumann 2017

Muscle action and “dart thrower’s position”

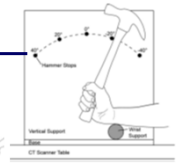




Neumann



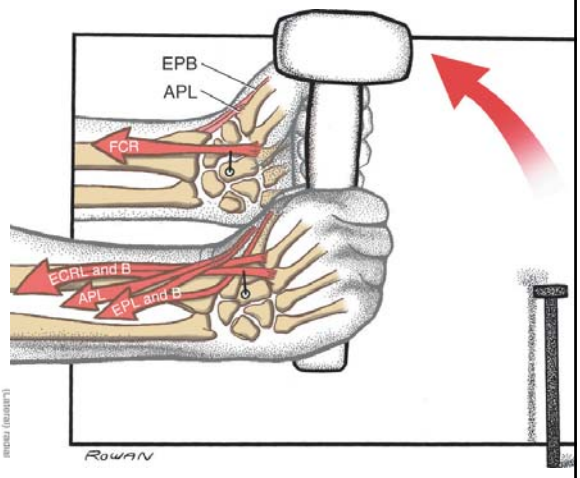
Path during hammering

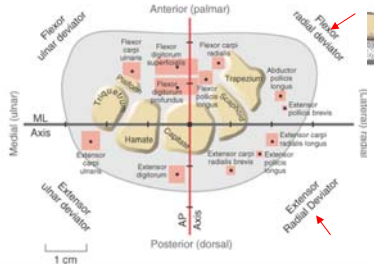


Leventhal et al: 2010

Radial Deviators of the Wrist

Extensor carpi radialis longus and brevis
Extensor pollicis longus
Extensor pollicis brevis
Flexor carpi radialis
Abductor pollicis longus
Flexor pollicis longus

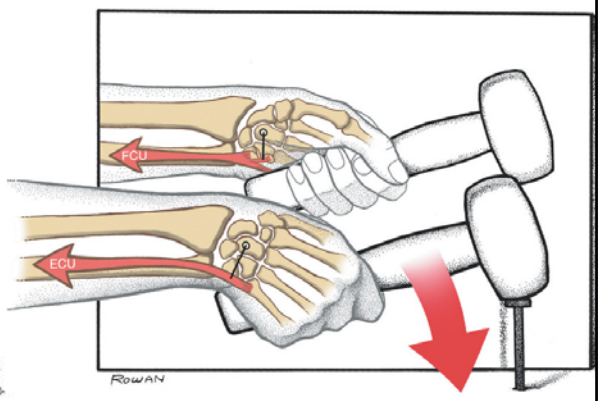


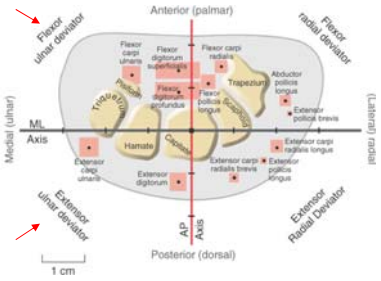


Neumann 2017

Ulnar Deviators of the Wrist

Flexor carpi ulnaris
Extensor carpi ulnaris
Flexors digit. profun and super.
Extensor digitorum

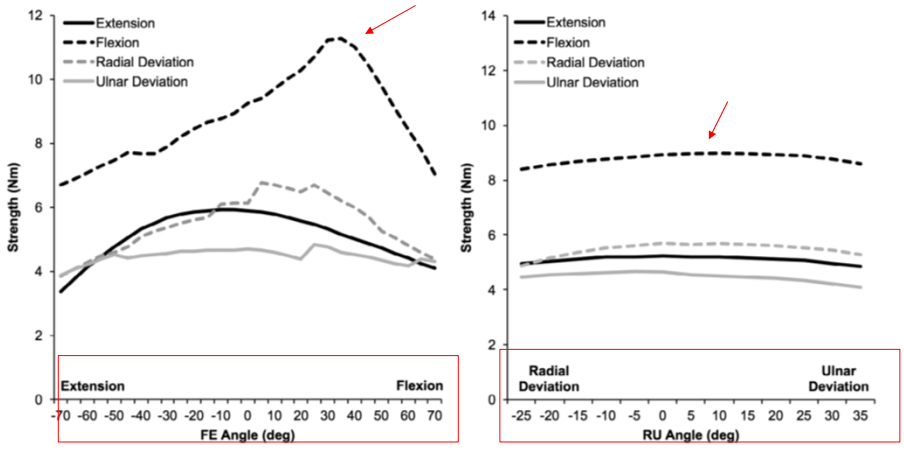




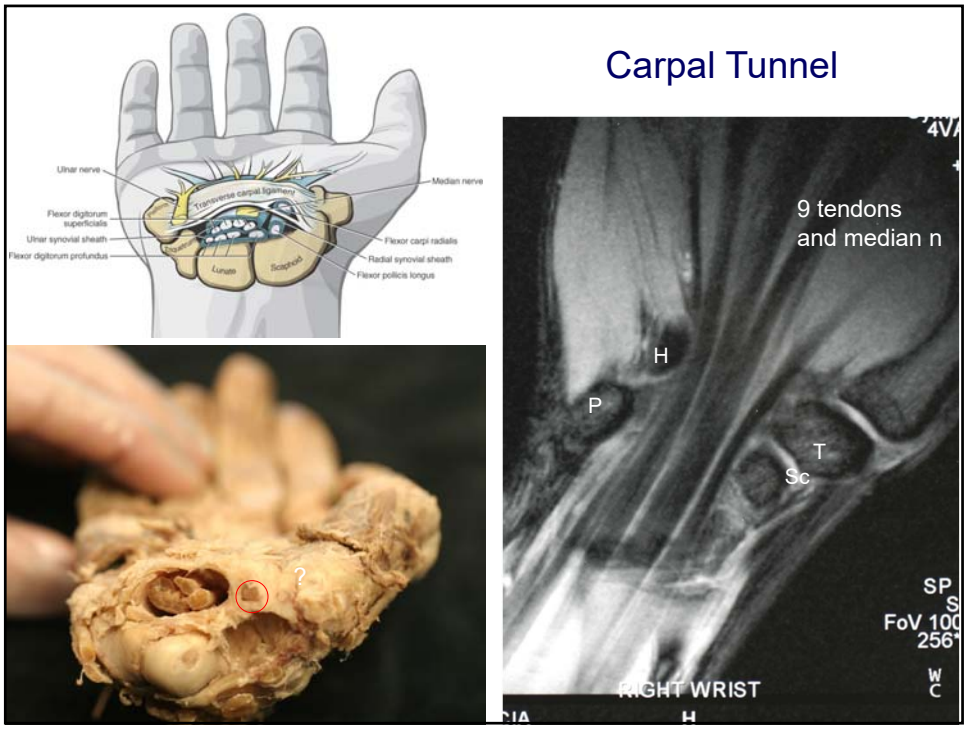
Neumann 2017

Wrist strength across all wrist positions

-Torques greatest for wrist flexor muscles, regardless of position.
-Wrist flexion strength greatest in a position of wrist flexion
The strength of the extensors, radial and ulnar deviators, are relativerly similar, regardless of wrist position



La Delfa and Potvin 2017


Carpal Tunnel
Ulnar nerve
Transverse carpal ligament
Median nerve
Flexor digitorum superficialis
Ulnar synovial sheath
Flexor digitorum profundus
Flexor carpi radialis
Radial synovial sheath
Flexor pollicis longus
Lunate
Scaphoid
?
9 tendons
and median n
H
P
T
Sc
SP
FoV 100
256
RIGHT WRIST
W
C

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