

# MRI and MR Arthrography of Intrinsic Carpal Ligaments and Triangular Fibrocartilage Complex

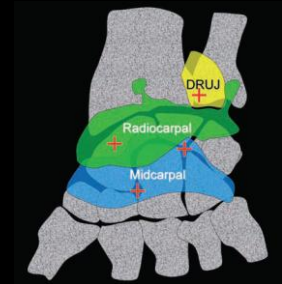
Fabio Becce

Department of Diagnostic and Interventional Radiology  
Lausanne University Hospital



## Joints

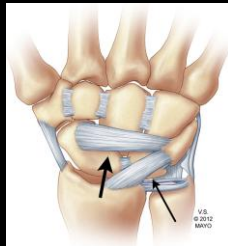
- Distal radioulnar (DRUJ)
- Radiocarpal
- Midcarpal



Moser et al. Multidetector CT arthrography of the wrist joint: how to do it. Radiographics. 2008

## Ligaments

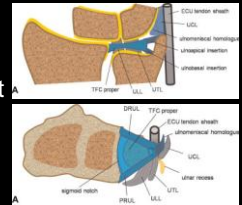
- Triangular fibrocartilage complex (TFCC)
- Intrinsic:
  - Interosseous
  - Capsular
- Extrinsic:
  - Palmar
  - Dorsal
  - Collateral



Ringler. MRI of wrist ligaments. J Hand Surg Am. 2013

## TFCC

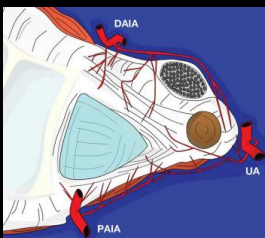
- TFC proper (articular disc)
- Radioulnar ligaments
- Ulnocarpal ligaments
- Ulnar collateral ligament
- Meniscus homologue
- Extensor carpi ulnaris tendon sheath



Nöbauer-Huhmann et al. Anatomy and variants of the triangular fibrocartilage complex and its MR appearance at 3 and 7 T. Semin Musculoskelet Radiol. 2012

## TFCC

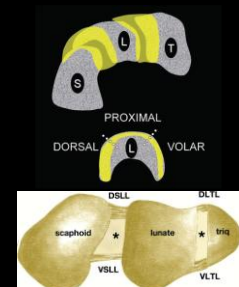
- Vascularization



Cerezal et al. MR and CT arthrography of the wrist. Semin Musculoskelet Radiol. 2012

## Intrinsic Ligaments

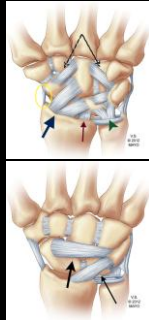
- Intrinsic interosseous:
  - Scapholunate (SL)
  - Lunotriquetral (LT)



Moser et al. Multidetector CT arthrography of the wrist joint: how to do it. Radiographics. 2008  
Cerezal et al. MR and CT arthrography of the wrist. Semin Musculoskelet Radiol. 2012

## Intrinsic Ligaments

- Intrinsic capsular:
  - Palmar scaphotriquetral ("arcuate")
  - Dorsal intercarpal



Ringler. MRI of wrist ligaments. J Hand Surg Am. 2013

## Extrinsic Ligaments

- Extrinsic palmar:
  - Radioscaphocapitate
  - Radiolunotriquetral
  - Ulnolunate
  - Ulnotriquetral



Taljanovic et al. US of the intrinsic and extrinsic wrist ligaments and triangular fibrocartilage complex - normal anatomy and imaging technique. Radiographics. 2011  
Nanno et al. Three-dimensional computed tomography of the carpal ligaments. Semin Musculoskelet Radiol. 2009

## Extrinsic Ligaments

- Extrinsic dorsal:
  - Radiotriquetral
  - Ulnotriquetral
- Extrinsic collateral:
  - Radial
  - Ulnar



Taljanovic et al. US of the intrinsic and extrinsic wrist ligaments and triangular fibrocartilage complex - normal anatomy and imaging technique. Radiographics. 2011  
Nanno et al. Three-dimensional computed tomography of the carpal ligaments. Semin Musculoskelet Radiol. 2009

## Imaging

- Radiography
- Ultrasonography
- Computed tomography (CT), CT arthrography
- Magnetic resonance imaging (MRI), MR arthrography (direct, indirect)

## MRI and MR Arthrography

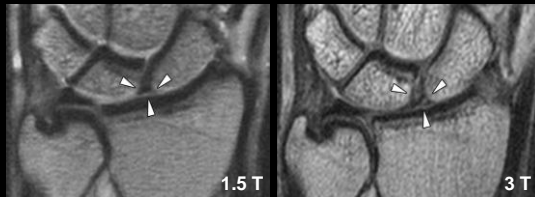
- System (field strength)
- Coil
- Patient position
- Protocol (sequences)

## Field Strength

- Advantages of 3-Tesla (T) imaging:
  - Increased signal-to-noise ratio (SNR)
    - Higher spatial resolution
    - Shorter image acquisition time
    - Higher contrast-to-noise ratio (CNR)
- Challenges at 3 T:
  - Specific absorption rate (SAR)
  - Artifacts

Saupe. 3-Tesla high-resolution MR imaging of the wrist. Semin Musculoskelet Radiol. 2009

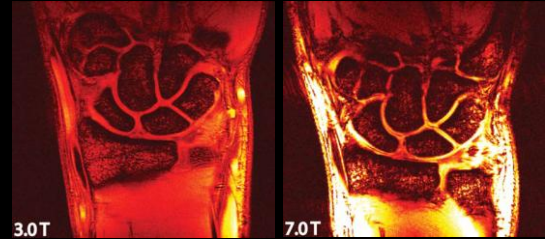
## Field Strength



Sauepe et al. MR imaging of the wrist: comparison between 1.5- and 3-T MR imaging—preliminary experience. Radiology. 2005

## Field Strength

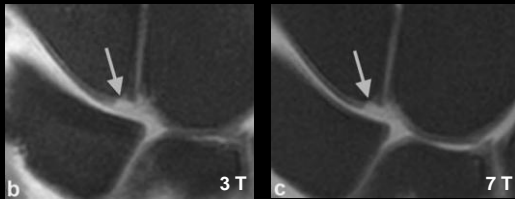
- Advantages of 7-T MRI



Nordmeyer-Massner et al. In vitro and in vivo comparison of wrist MR imaging at 3.0 and 7.0 Tesla using a gradient echo sequence and identical eight-channel coil array designs. J Magn Reson Imaging. 2011

## Field Strength

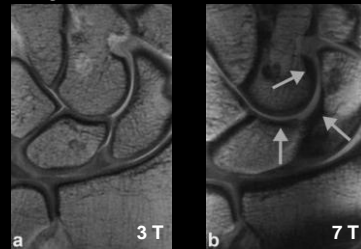
- Advantages of 7-T MR arthrography



Donati et al. Direct MR arthrography of cadaveric wrists: comparison between MR imaging at 3.0T and 7.0T and gross pathologic inspection. J Magn Reson Imaging. 2011

## Field Strength

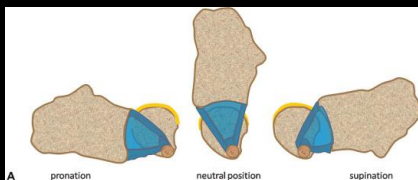
- Challenges at 7 T



Donati et al. Direct MR arthrography of cadaveric wrists: comparison between MR imaging at 3.0T and 7.0T and gross pathologic inspection. J Magn Reson Imaging. 2011

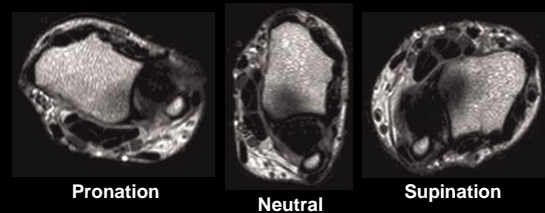
## Patient Position

- Prone, wrist over the head ("Superman")
- Supine, wrist at the side



Pfirrmann et al. What happens to the triangular fibrocartilage complex during pronation and supination of the forearm? Analysis of its morphology and diagnostic assessment with MR arthrography. Skeletal Radiol. 2001  
Nöbauer-Huhmann et al. Anatomy and variants of the triangular fibrocartilage complex and its MR appearance at 3 and 7 T. Semin Musculoskelet Radiol. 2012

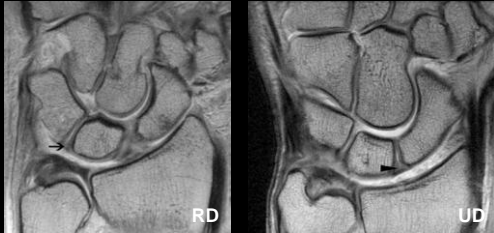
## Patient Position



Pfirrmann et al. What happens to the triangular fibrocartilage complex during pronation and supination of the forearm? Analysis of its morphology and diagnostic assessment with MR arthrography. Skeletal Radiol. 2001  
Nöbauer-Huhmann et al. Anatomy and variants of the triangular fibrocartilage complex and its MR appearance at 3 and 7 T. Semin Musculoskelet Radiol. 2012

## Patient Position

- Wrist in radial or ulnar deviation



Gheno et al. Differences between radial and ulnar deviation of the wrist in the study of the intrinsic intercarpal ligaments: magnetic resonance imaging and gross anatomic inspection in cadavers. *Skeletal Radiol.* 2010

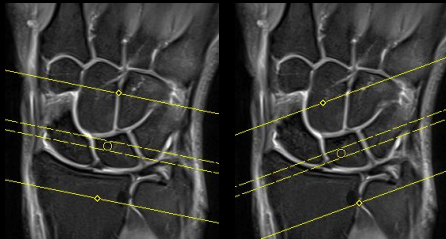
## MRI Protocol

- Axial and/or coronal T1-w TSE
- Coronal proton density (PD)-w with/without fat-suppression (FS)
- Axial T2-w TSE FS
- Sagittal PD-w with/without FS
- (Gd-enhanced iv. 3D T1-w GRE FS)

Chhabra et al. Current perspectives on the advantages of 3-T MR imaging of the wrist. *Radiographics.* 2012

## MRI Protocol

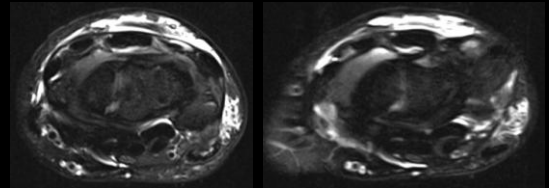
- Axial oblique vs. true axial plane



Robinson et al. Axial oblique MR imaging of the intrinsic ligaments of the wrist: initial experience. *Skeletal Radiol.* 2006

## MRI Protocol

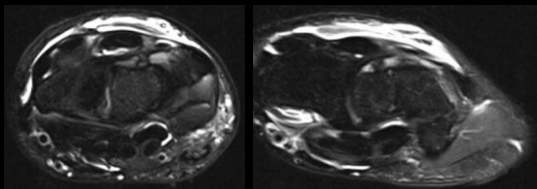
- Axial oblique vs. true axial plane



Robinson et al. Axial oblique MR imaging of the intrinsic ligaments of the wrist: initial experience. *Skeletal Radiol.* 2006

## MRI Protocol

- Axial oblique vs. true axial plane



Robinson et al. Axial oblique MR imaging of the intrinsic ligaments of the wrist: initial experience. *Skeletal Radiol.* 2006

## MRI Protocol

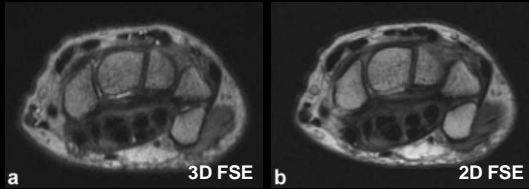
- 3D FSE vs. 2D FSE sequence



Stevens et al. Imaging of the wrist at 1.5 Tesla using isotropic three-dimensional fast spin echo cube. *J Magn Reson Imaging.* 2011

## MRI Protocol

- 3D FSE vs. 2D FSE sequence



Stevens et al. Imaging of the wrist at 1.5 Tesla using isotropic three-dimensional fast spin echo cube. J Magn Reson Imaging. 2011

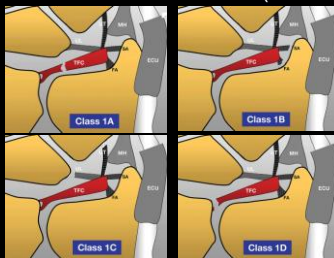
## MRI

- Criteria for TFCC tears:
  - Degeneration (asymptomatic): increased signal intensity on T1- or PD-w images
  - Defect/Tear (asymptomatic/symptomatic): increased signal intensity on fluid-sensitive FS images extending to surface, associated with DRUJ effusion
  - Acute (0-3 months), subacute (3-12 months), chronic (>1 year)

Chhabra et al. Current perspectives on the advantages of 3-T MR imaging of the wrist. Radiographics. 2012  
Cerezal et al. MR and CT arthrography of the wrist. Semin Musculoskelet Radiol. 2012

## MRI

- TFCC tears: Palmer class 1 (traumatic)



Cerezal et al. MR and CT arthrography of the wrist. Semin Musculoskelet Radiol. 2012

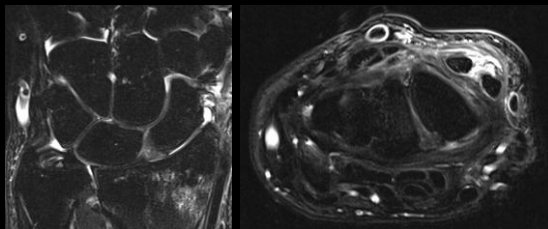
## MRI

- TFCC tears: Palmer class 2 (degenerative)
  - 2A: TFCC wear
  - 2B: 2A + lunate or ulnar chondromalacia
  - 2C: TFCC perforation, lunate or ulnar chondromalacia
  - 2D: 2C + LT ligament tear
  - 2E: 2D + ulnocarpal osteoarthritis

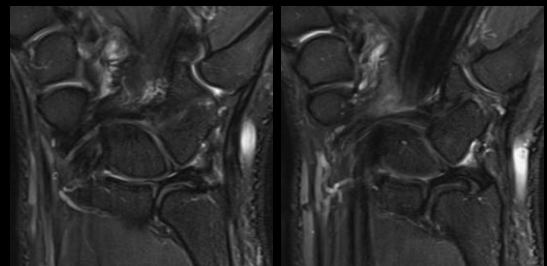


Palmer. Triangular fibrocartilage complex lesions: a classification. J Hand Surg Am. 1989  
Cerezal et al. MR and CT arthrography of the wrist. Semin Musculoskelet Radiol. 2012

## TFCC Tears



## Pitfalls



Pfrrmann et al. Variants, pitfalls and asymptomatic findings in wrist and hand imaging. Eur J Radiol. 2005

## MRI

- Criteria for intrinsic interosseous ligament tears:
  - Increased signal intensity on fluid-sensitive FS images
  - Morphologic distortion or complete absence
  - Secondary SL dissociation (>3 mm), carpal arch disruption, ganglion cyst formation

Chhabra et al. Current perspectives on the advantages of 3-T MR imaging of the wrist. Radiographics. 2012

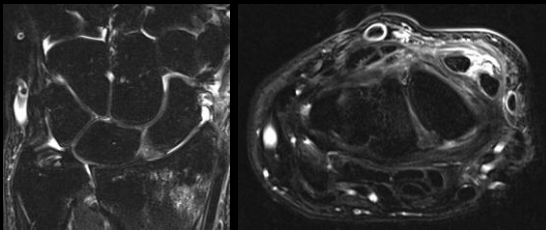
## MRI

- Intrinsic interosseous ligament tears



Moser et al. Multidetector CT arthrography of the wrist joint: how to do it. Radiographics. 2008

## Intrinsic Ligament Tears

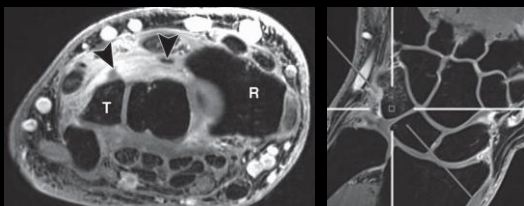


## MRI

- Criteria for extrinsic ligament injuries:
  - Acute sprain (grade 1): periligamentous edema
  - Partial tear (grade 2): thickening due to peri- and intraligamentous edema
  - Complete tear (grade 3): complete disruption
  - Traction-related avulsive cystic changes
  - Soft-tissue ganglion cysts

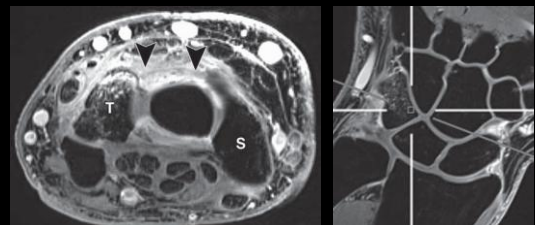
Chhabra et al. Current perspectives on the advantages of 3-T MR imaging of the wrist. Radiographics. 2012

## Extrinsic Ligament Tears



Becco et al. Dorsal fractures of the triquetrum: MRI findings with an emphasis on dorsal carpal ligament injuries. Am J Roentgenol. 2013

## Extrinsic Ligament Tears



Becco et al. Dorsal fractures of the triquetrum: MRI findings with an emphasis on dorsal carpal ligament injuries. Am J Roentgenol. 2013



## Direct MR Arthrography

- Exploits the natural advantages gained from joint effusion:
  - Distends the joint capsule
  - Outlines intra-articular structures
  - Leaks into abnormalities

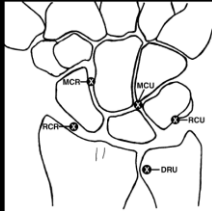
## Indications

- TFCC tears
- SL and/or LT ligament tears
- Articular cartilage lesions
- Intra-articular (“loose”) bodies

Cerezal et al. Wrist MR arthrography: how, why, when. Radiol Clin N Am. 2005  
Lomasney et al. Magnetic resonance arthrography of the upper extremity. Radiol Clin N Am. 2013

## Approaches

- Dorsal:
  - Unicompartmental (radiocarpal) arthrography
  - Bicompartamental
  - Tricompartmental



Cerezal et al. Wrist MR arthrography: how, why, when. Radiol Clin N Am. 2005

## Approaches

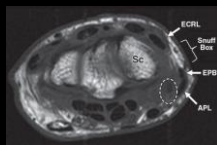
- DRUJ arthrography



Zanetti et al. Characteristics of triangular fibrocartilage defects in symptomatic and contralateral asymptomatic wrists. Radiology. 2000  
Rüeggeler et al. Peripheral tear of the triangular fibrocartilage: depiction with MR arthrography of the distal radioulnar joint. Am J Roentgenol. 2007

## Approaches

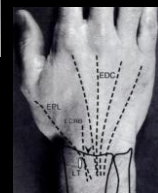
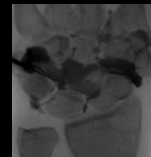
- Lateral (radiocarpal)



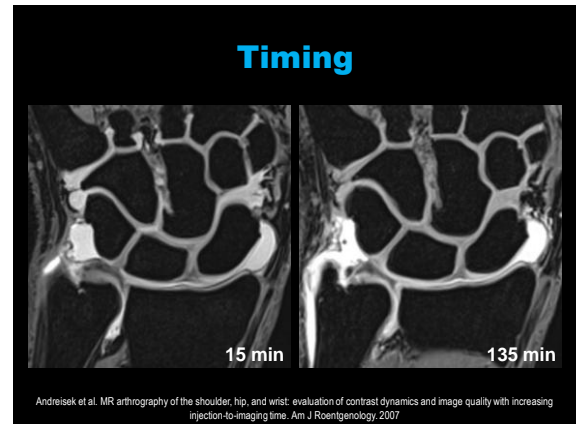
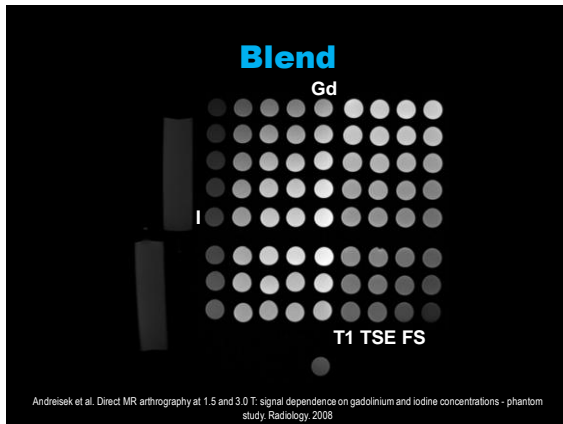
Medved et al. Lateral approach for radiocarpal wrist arthrography. Am J Roentgenol. 2011

## Guidance

- Fluoroscopic
- Sonographic
- CT
- MR
- Clinical landmarks



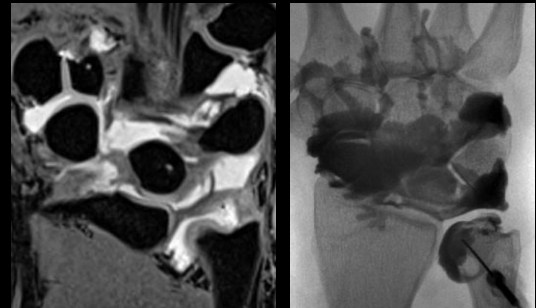
Beaulieu et al. MR arthrography of the wrist: scanning-room injection of the radiocarpal joint based on clinical landmarks. Am J Roentgenol. 1998



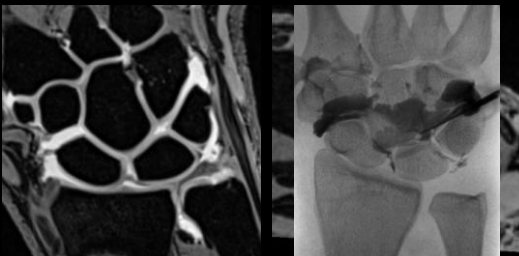
## MR Arthrography Protocol

- Axial, coronal and sagittal T1-w TSE FS and/or 3D T1-w GRE FS
- Coronal PD-w FS
- Axial T2-w TSE FS

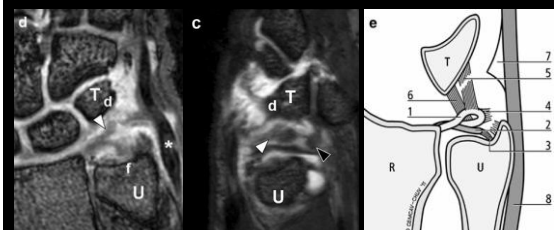
## TFCC Tears



## TFCC Tears



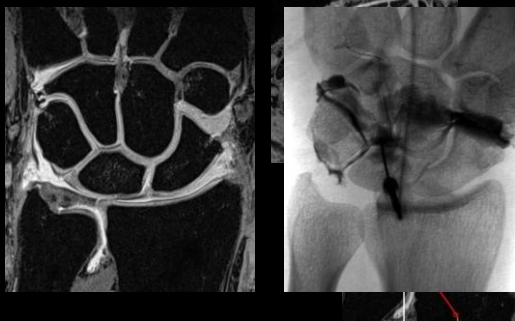
## TFCC Tears



Theumann et al. Bucket-handle tear of the triangular fibrocartilage complex: case report of a complex peripheral injury with separation of the distal radioulnar ligaments from the articular disc. Skeletal Radiol. 2011



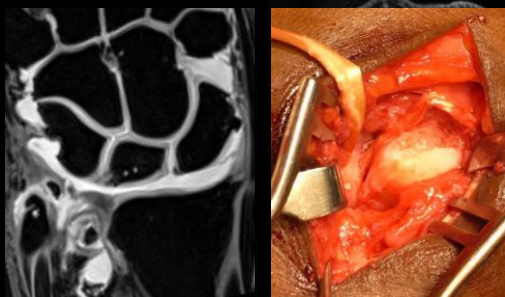
## Intrinsic Ligament Tears



## Intrinsic Ligament Tears

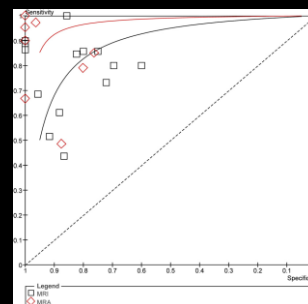


## Intrinsic Ligament Tears



## Diagnostic Performance

- TFCC tears



Smith et al. Diagnostic accuracy of magnetic resonance imaging and magnetic resonance arthrography for triangular fibrocartilaginous complex injury. J Bone Joint Surg Am. 2012

## Diagnostic Performance

	MRI			MR Arthrography		
	TFCC	SL	LT	TFCC	SL	LT
<b>Sensitivity</b>	0.44-1 (0.75)	0.59-0.89	0.04-0.50	0.48-1 (0.84)	0.68-1	0.50-0.82
<b>Specificity</b>	0.60-1 (0.81)	0.70-1	0.90-0.97	0.76-1 (0.95)	0.87-1	0.94-1

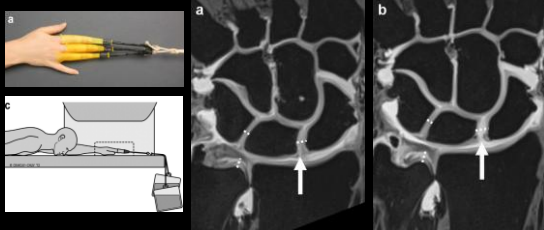
Smith et al. Diagnostic accuracy of magnetic resonance imaging and magnetic resonance arthrography for triangular fibrocartilaginous complex injury. J Bone Joint Surg Am. 2012  
Rungler. MRI of wrist ligaments. J Hand Surg Am. 2013

## Diagnostic Performance

	1.5 T	3 T	p
<b>Sensitivity</b>			
TFCC	0.82	0.90	0.493
SL	0.57	0.70	0.482
LT	0.22	0.50	0.114
<b>Specificity</b>			
TFCC	0.59	0.74	0.378
SL	0.83	0.94	0.051
LT	0.94	0.94	0.898

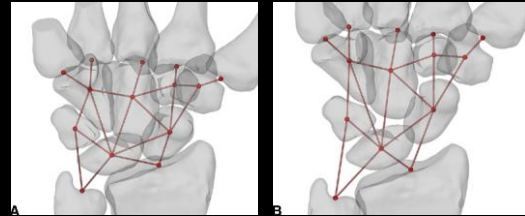
Anderson et al. Diagnostic comparison of 1.5 Tesla and 3.0 Tesla preoperative MRI of the wrist in patients with ulnar-sided wrist pain. J Hand Surg Am. 2008

## Traction



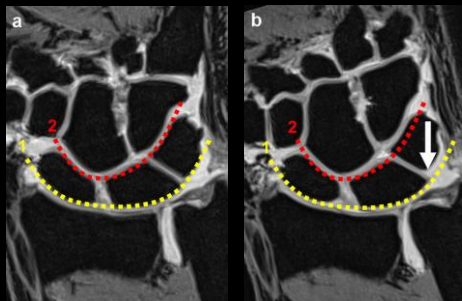
Cerny et al. 3-T direct MR arthrography of the wrist: value of finger trap distraction to assess intrinsic ligament and triangular fibrocartilage complex tears. Eur J Radiol. 2013

## Traction



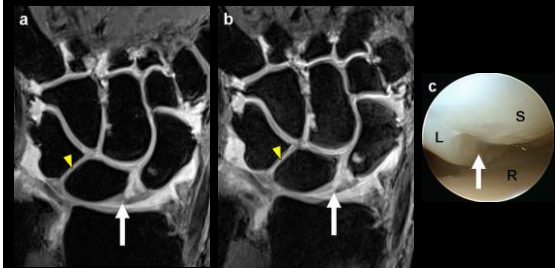
Leventhal et al. Conformational changes in the carpus during finger trap distraction. J Hand Surg Am. 2010

## Traction



Cerny et al. 3-T direct MR arthrography of the wrist: value of finger trap distraction to assess intrinsic ligament and triangular fibrocartilage complex tears. Eur J Radiol. 2013

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Cerny et al. 3-T direct MR arthrography of the wrist: value of finger trap distraction to assess intrinsic ligament and triangular fibrocartilage complex tears. Eur J Radiol. 2013