

# MRI Protocols of the ESSR Arthritis Subcommittee



Recommendations of the ESSR Arthritis Subcommittee for the Use of Magnetic Resonance Imaging in Musculoskeletal Rheumatic Diseases. *Semin Musculoskelet Radiol* 2015;19:396–411

# MRI Protocols

- Ankle
- Anterior Chest Wall in Arthritis
- Cervical Spine in Rheumatoid Arthritis
- Elbow
- Foot
- Hand and Wrist
- Hip
- Knee
- Sacroiliac Joints
- Shoulder
- Spine in Spondyloarthritis
- Temporomandibular Joint
- Whole Body MRI for Chronic Recurrent Multifocal Osteomyelitis



# Ankle

## MRI Protocols of the ESSR Arthritis Subcommittee

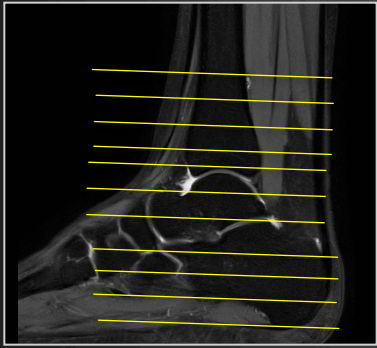


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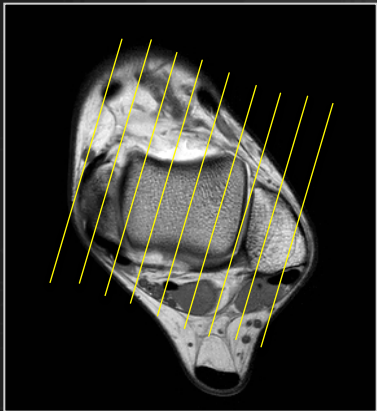
# MRI scan

- Patient in supine position with feet first
- Dedicated coil
- Foot close to neutral position, avoiding any plantar or dorsiflexion

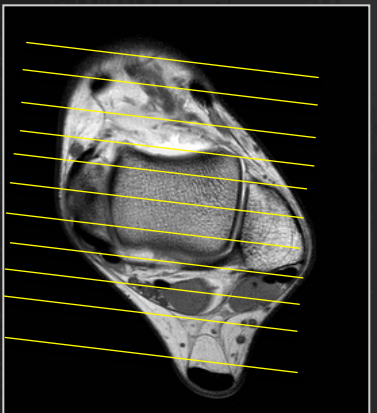
# Localizer



Axial plane: 90° alignment to the tibia



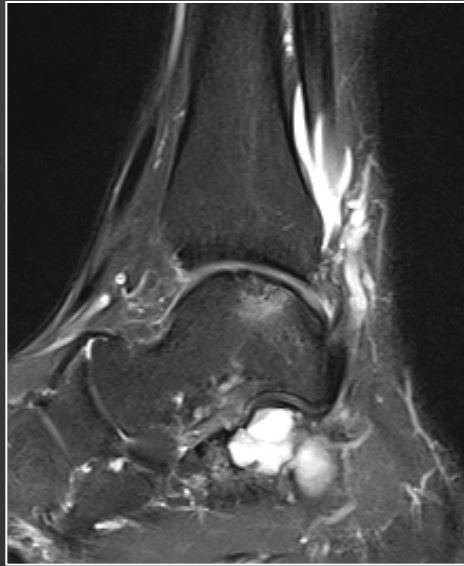
Sagittal plane: 90° alignment to the intermalleolar axis; the skin surrounding the hindfoot has to be included



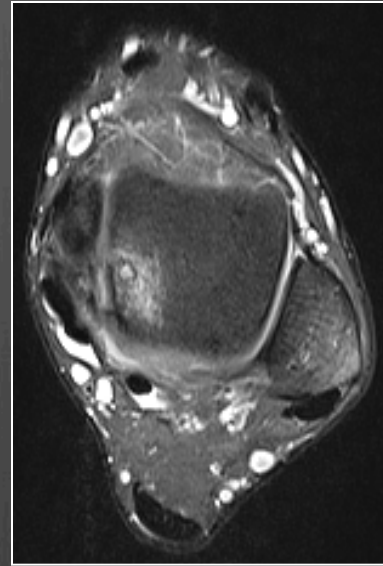
Coronal plane: aligned to the intermalleolar axis

# Recommended sequences

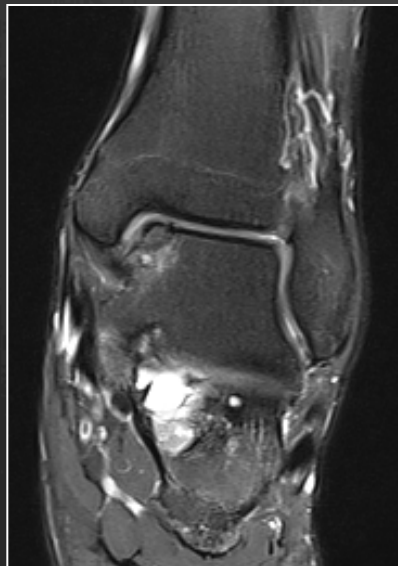
Sag PD FS



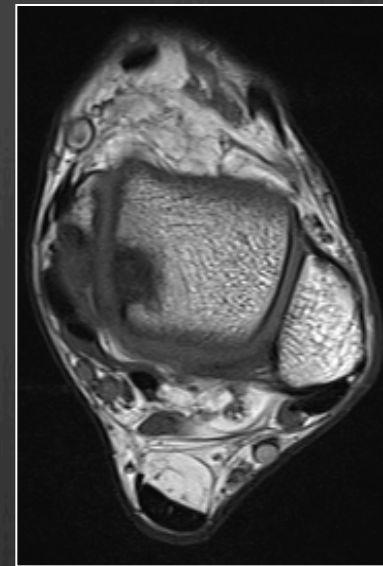
Ax PD FS



Cor PD FS



Ax T1



# MRI protocol

Recommended Sequences	FOV (mm)	Slice thickness (mm)	TR (ms)	TE (ms)	Matrix
Sag PD FS	180	3	80-100	10-20	320 x 288
Cor PD FS	160	3	80-100	10-20	256x230
Ax PD FS	160	3	80-100	10-20	256x218
Ax T1	160	3	500	20	256x18
CE-Sag T1 FS*	180	3	650-750	18	320x288
CE Ax T1 FS*	160	3	650-750	18	256x218

\*if optimal assessment of synovitis/osteitis is needed

# Anterior Chest Wall in Arthritis

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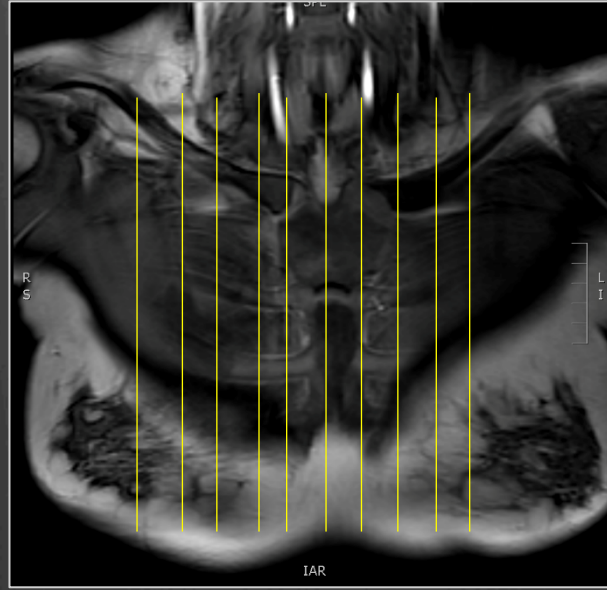
# MRI scan

- Patient in prone or supine position
- Surface coil
- Coil size depends on the examined area: whole steno-costo-clavicular region or sterno-clavicular joints

# Localizers whole sterno-costo-clavicular region



Coronal slices



Sagittal slices



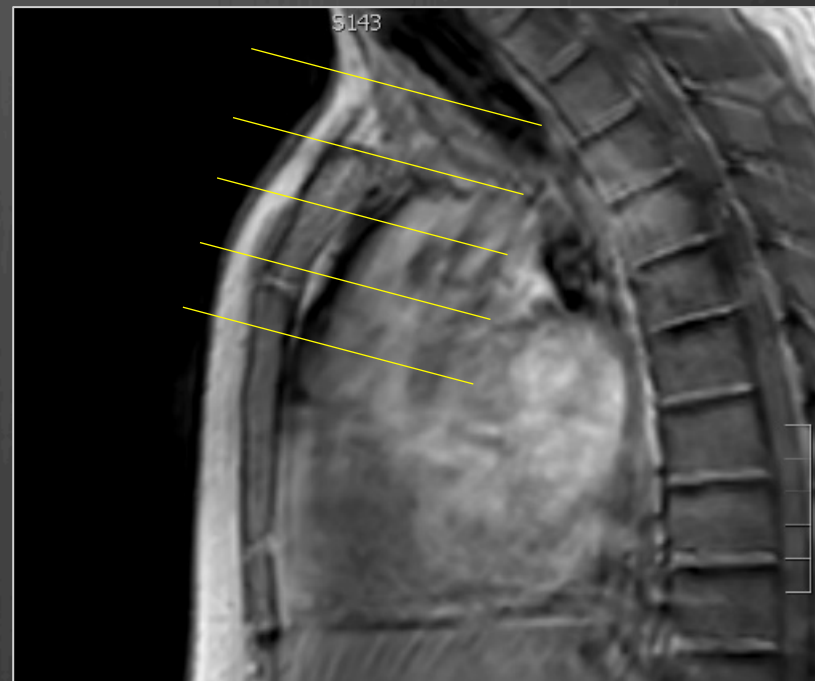
Axial slices



# Localizers sterno-clavicular joint

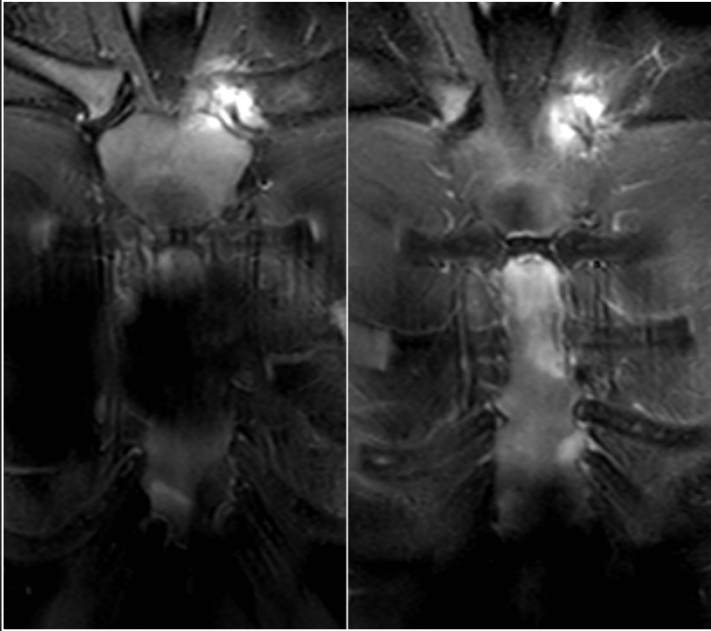


Coronal slices



Axial slices

# Recommended sequences whole sterno-costo-clavicular region



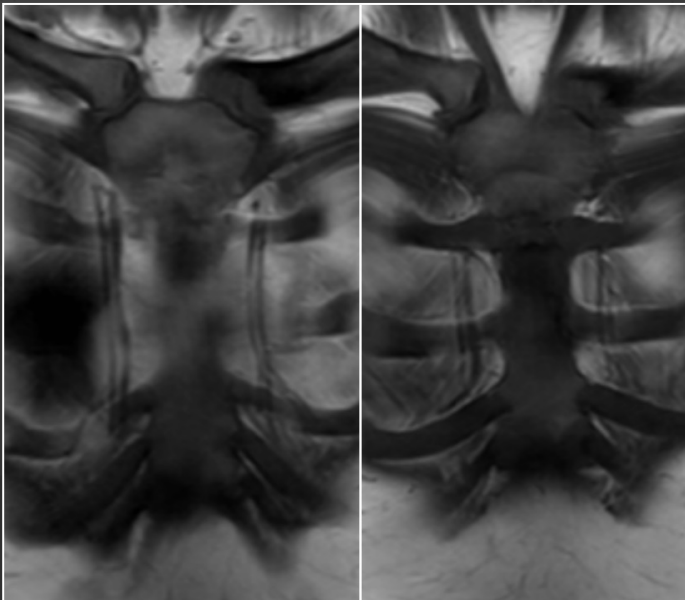
Cor STIR



Cor T1

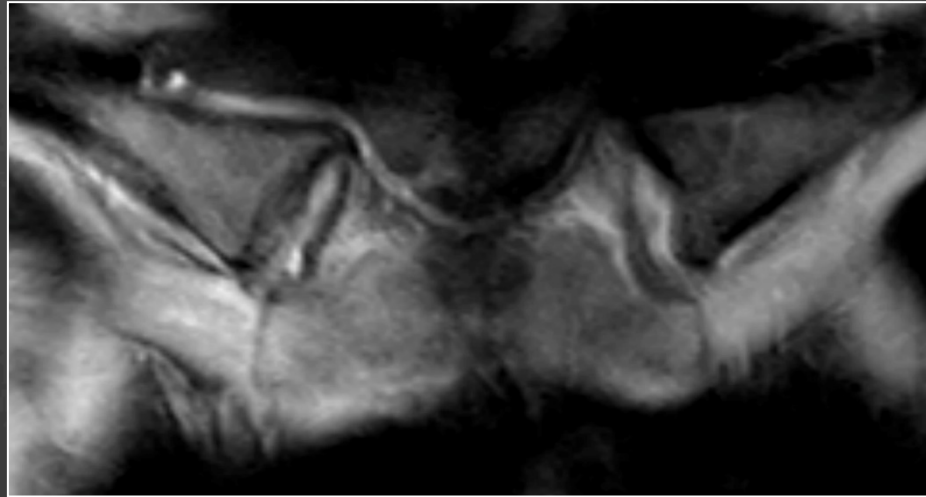


Sag T2 FS

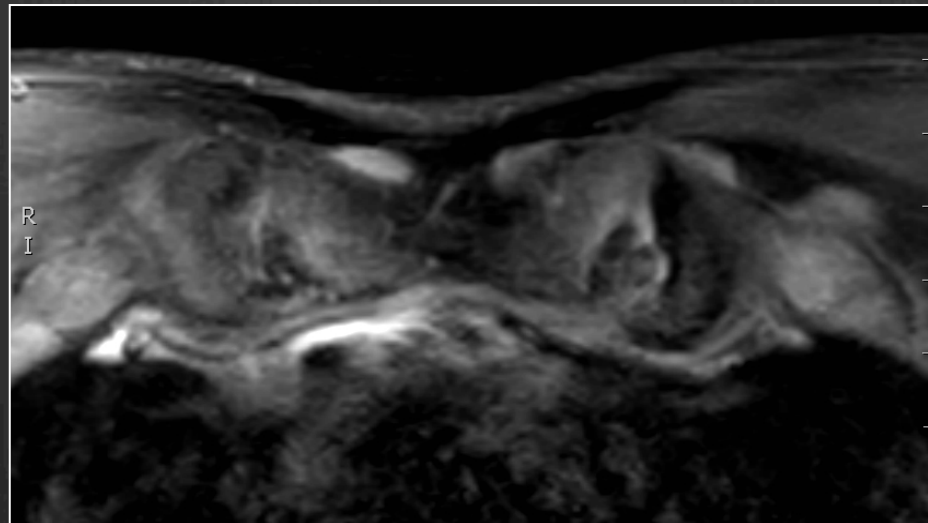


# Recommended sequences sterno-clavicular joint

Cor PD FS



Ax PD FS



# MRI protocol whole sterno-costo-clavicular region

	FOV (mm)	Slice (mm)	TR (ms)	TE (ms)	Matrix
Cor T1	300	3	500-700	10-20	320
Cor STIR	300	3	2200-2600	60-80	320
Sag or Ax T2	300	3	2400-2800	65-85	320

# MRI protocol sterno-clavicular joint

	FOV (mm)	Slice (mm)	TR (ms)	TE (ms)	Matrix
Cor PD FS	250	3	1900-2100	15-25	400
Ax PD FS	250	3	1900-2100	15-25	400
T1 FS	250	3	500-700	10-20	400
CE T1 FS*	250	3	500-700	10-20	400

\*if optimal assessment of synovitis/osteitis is needed

# Cervical Spine in Rheumatoid Arthritis

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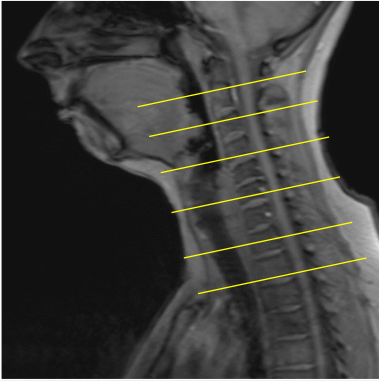


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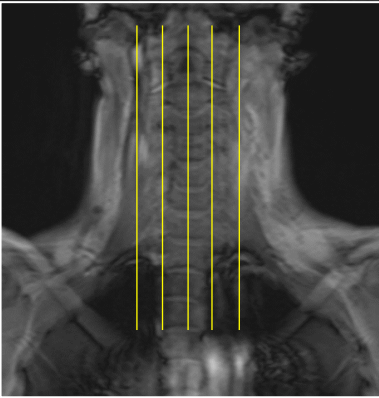
# MRI scan

- Patient positioning: Head first supine
- Coils: Head and neck
- Immobilize the head with cushions

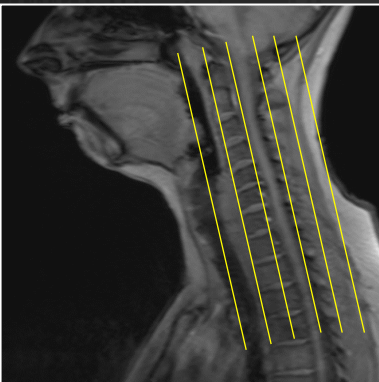
# Localizer



*Axial plane:* cover the entire cervical spine



*Sagittal plane:* from the right to the left transverse process



*Coronal plane:* cover the entire vertebral column



# Recommended sequences

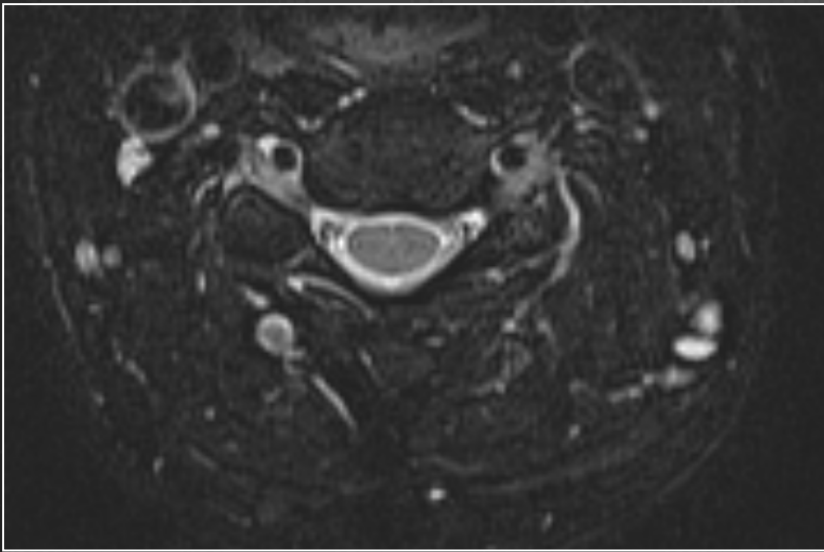


Sag T1

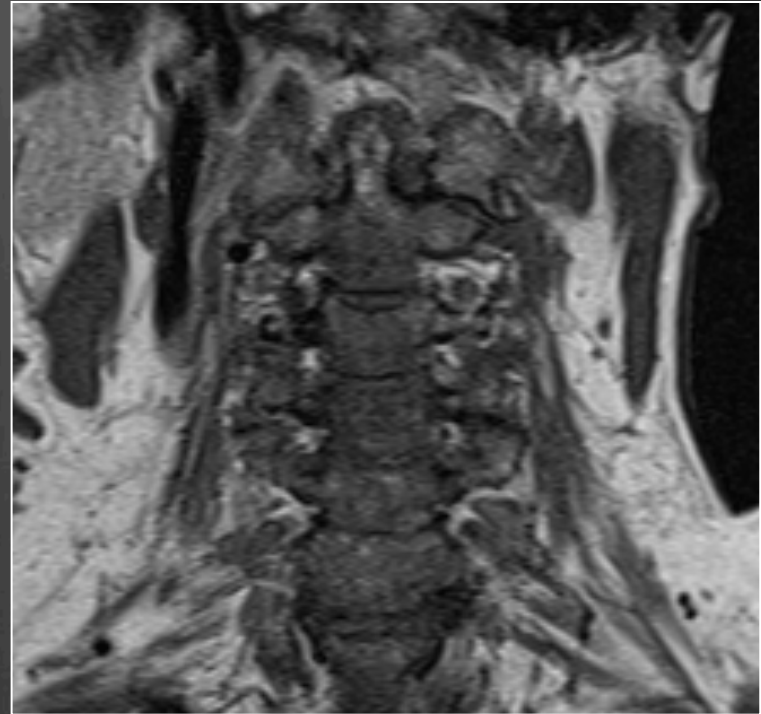


Sag STIR

# Recommended sequences

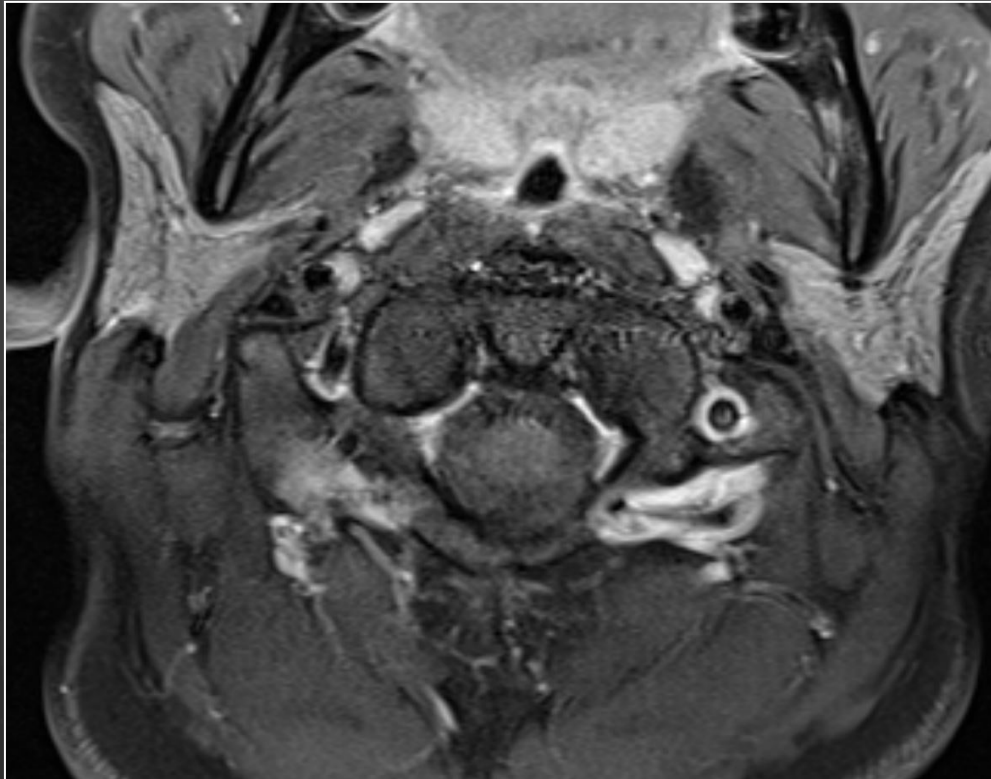


Ax T2 FS



Cor T1

# Recommended sequences



Ax T1 FS CE

# MRI protocol

Recommended Sequences <sup>#</sup>	FOV (mm)	Slice thickness (mm)	TR (ms)	TE (ms)	Matrix
Sag T1	280	3	4500	92	288x512
Sag STIR	300	3	3500	70	224x320
Ax T1	240	3	649	10	288x384
Ax T2 FS <sup>a</sup>	160	3	568	19	224x320
Sag CE T1 FS <sup>*</sup>	300	3	600	11	224x320
Ax CE T1 FS <sup>*</sup>	240	3	700	10	288x384

<sup>#</sup>Coronal T1 in cases with atlantoaxial and/or atlanto-occipital changes suggesting lateral or rotatory subluxation

<sup>a</sup>Axial T2 FS of the atlantoaxial, atlanto-occipital and, when needed, subaxial region

<sup>\*</sup>Postcontrast sagittal and axial T1 (FS) for clear delineation of active inflammation

# Elbow

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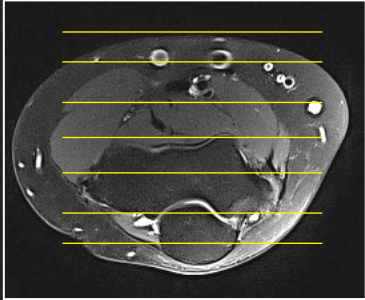
# MRI scan

## Patient positioning

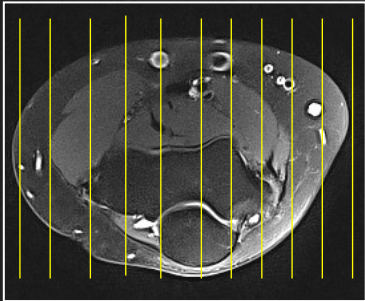
(depends on the habitus and range of motion)

- supine position with flex coil
- prone (*Superman* position) with knee or flex coil

# Localizer



*Coronal plane:* cover the entire joint from the anterior to the posterior skin surface



*Sagittal plane:* cover the entire joint from the medial to the lateral side



*Axial plane:* from two slices above the olecranon fossa to two slices below the radial tuberosity

# Recommended Sequences



Cor T1



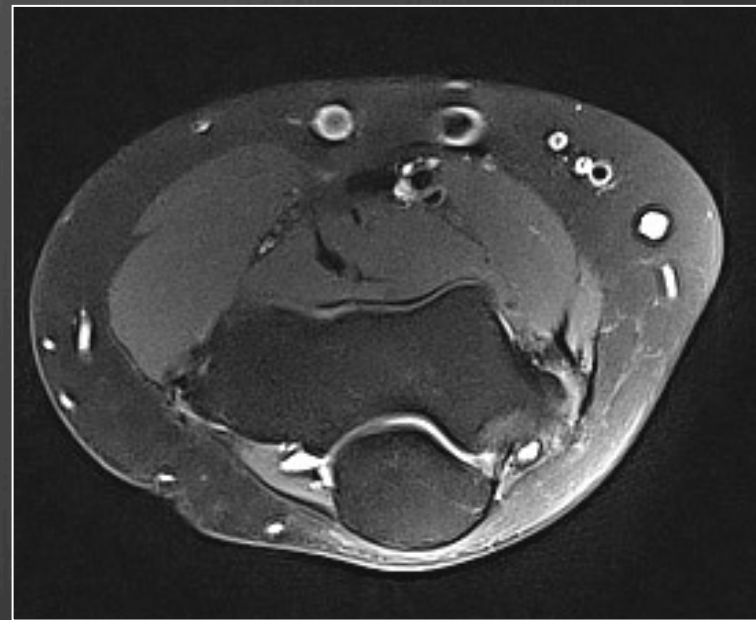
Cor PD FS  
(or STIR/TIRM or T2 FS)



# Recommended Sequences

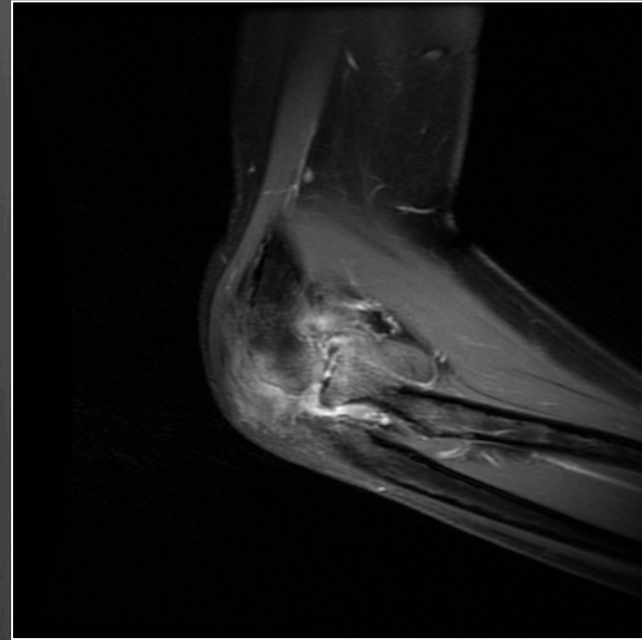
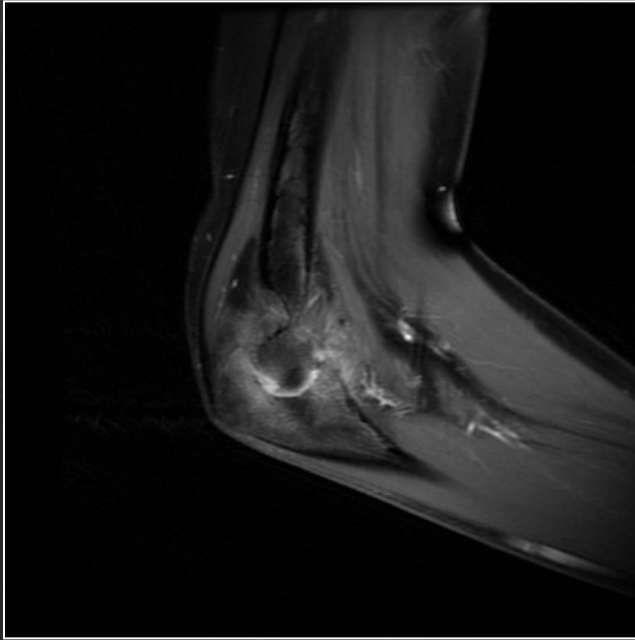


Sag PD FS



Ax PD FS  
(or STIR/TIRM or T2 FS)

# Optional Sequences



Sag T1 FS CE

# MRI protocol

Recommended Sequences <sup>1</sup>	FOV (mm)	Slice thickness (mm)	TR (ms)	TE (ms)	Matrix
Cor T1	160x160	2.5	765	11	320x304
Ax PD FS	150x150	3	2200	57	384x384
Sag PD FS	160x160	2.5	4340	72	384x384
Cor PD FS	160x160	2.5	2000	61	384x384
CE T1 FS*	160x160	2.5	400	15	384x384

<sup>1</sup>Modified parameters should be applied with T2 FS and STIR/TIRM

\*if optimal assessment of synovitis/osteitis is needed

# Foot

## MRI Protocols of the ESSR Arthritis Subcommittee

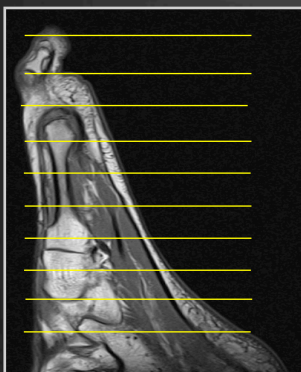


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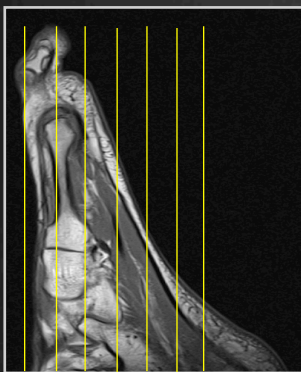
# MRI scan

- Patient in supine position with feet first
- Foot in slight (10 degree) plantar flexion
- Surface coil
- Adequate immobilisation (padding)

# Localizer



*Axial plane:* perpendicular to the metatarsal and phalanges bones. Cover the foot from the tip of the toe to the tarsal bones



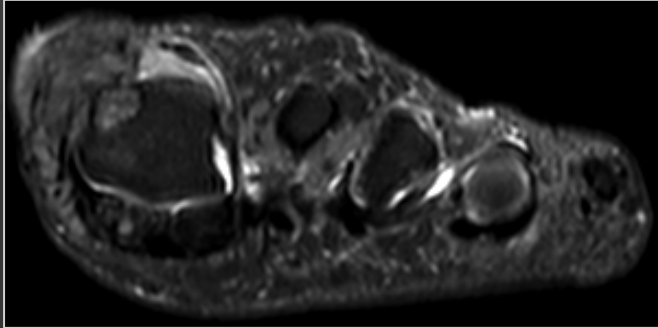
*Coronal plane:* parallel to the metatarsal and phalanges bones. Cover the foot from the dorsal to the plantar surface



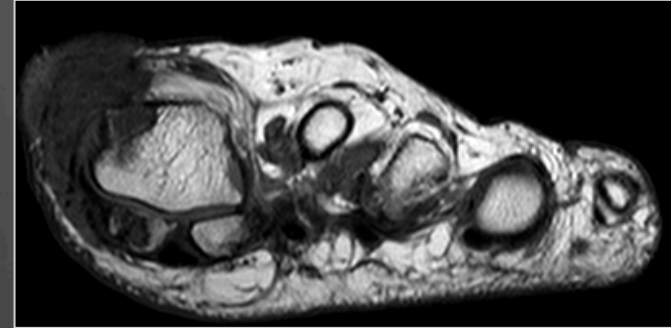
*Sagittal plane:* parallel to the metatarsal and phalanges bones. Cover the foot from side to side

# Recommended sequences

Ax PD FS  
(or STIR/TIRM  
or T2 FS)



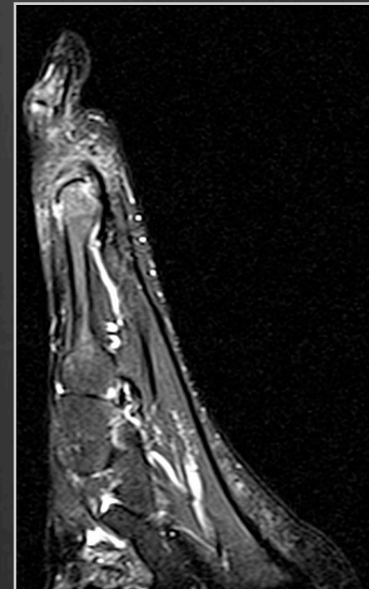
Ax T1



Cor PD FS  
(or STIR or  
TIRM or T2  
FS)



Sag PD FS



# MRI protocols

Recommended Sequences	FOV (cm)	Slice thickness (mm)	TR (ms)	TE (ms)	Matrix
Sag PD FS	8-10	3	3500	40	288x384
Ax STIR or T2 FS or PD FS	8-10	3	1800	25	192x256
Ax T1	8-10	3	400	15	288x380
Cor T2 FS or STIR or PD FS	8-10	3	3000	110	256x220



# Hand and Wrist

## MRI Protocols of the ESSR Arthritis Subcommittee



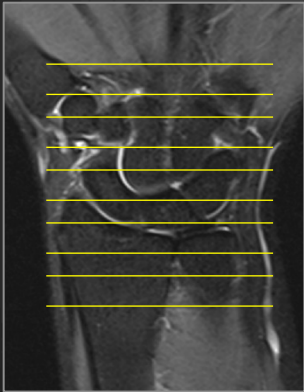
Recommendations of the ESSR Arthritis Subcommittee for the Use of Magnetic Resonance Imaging in Musculoskeletal Rheumatic Diseases. Semin Musculoskelet Radiol 2015;19:396–411

# MRI scan

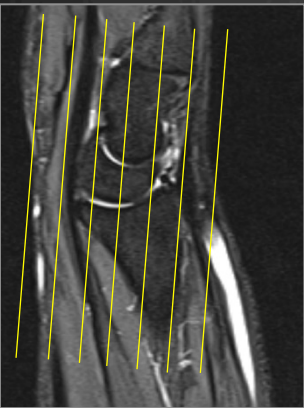
- Patient head first, prone with arm up (e.g., *Superman* position)
- Wrist/hand at the centre of the bore to ensure field homogeneity
- Coils: dedicated wrist/hand coil
- Immobilisation: tape hand to maintain position



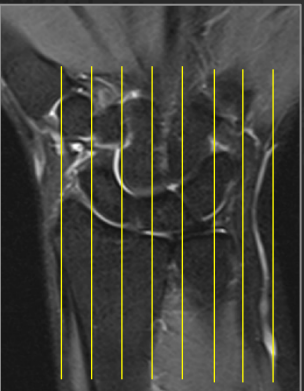
# Localizer wrist



*Axial plane* : from 3-4 cm proximal to the radiocarpal joint to 2 cm distal to the carpometacarpal joint

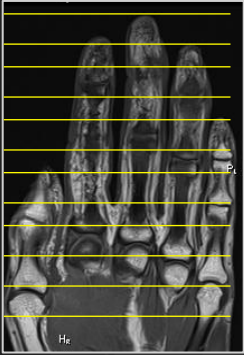


*Coronal plane*: skin to skin traversing the joint anteriorly to posteriorly to include the same field of view as the axial images



*Sagittal plane*: skin to skin perpendicular to the coronal

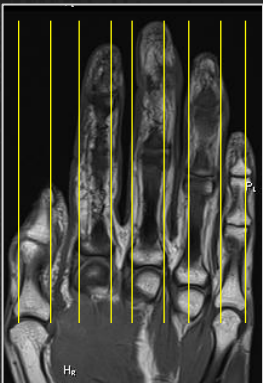
# Localizer Hand



*Axial plane:* from 2 cm proximal to the most proximal joint to 2 cm distally to the most distal joint of interest



*Coronal plane:* skin to skin traversing the joint anteriorly to posteriorly to include the same field of view as the axial images



*Sagittal plane:* skin to skin perpendicular to the coronal plane, to include the same field of view as the axial images

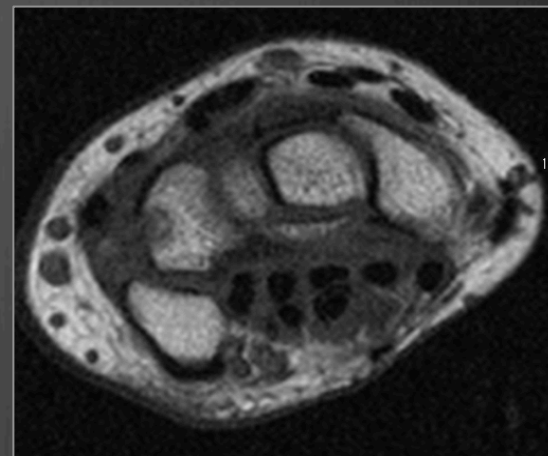
## Recommended sequences - Wrist



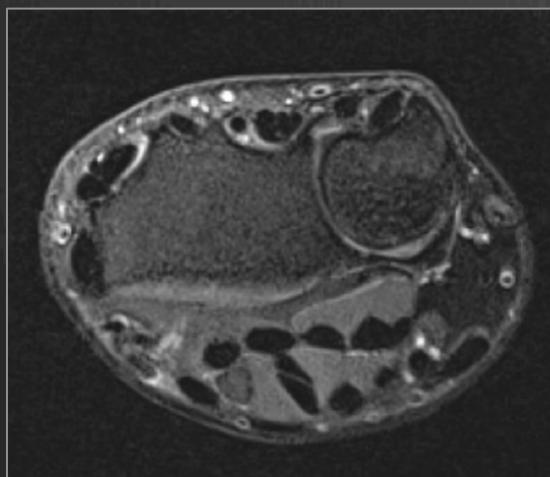
Cor STIR  
(or TIRM or T2 FS)



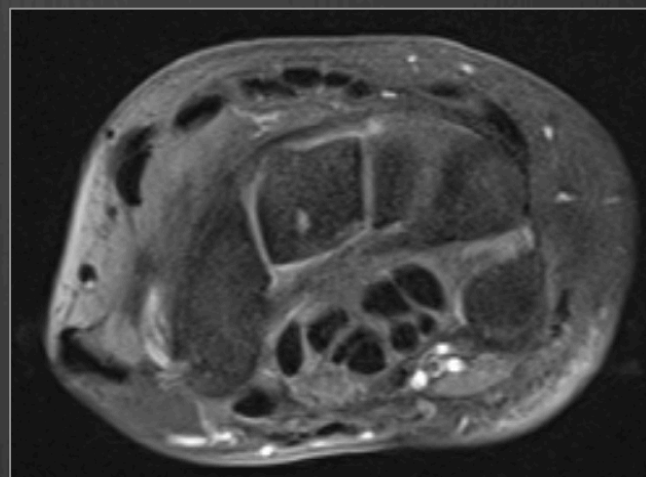
Cor T1w



Ax T1w

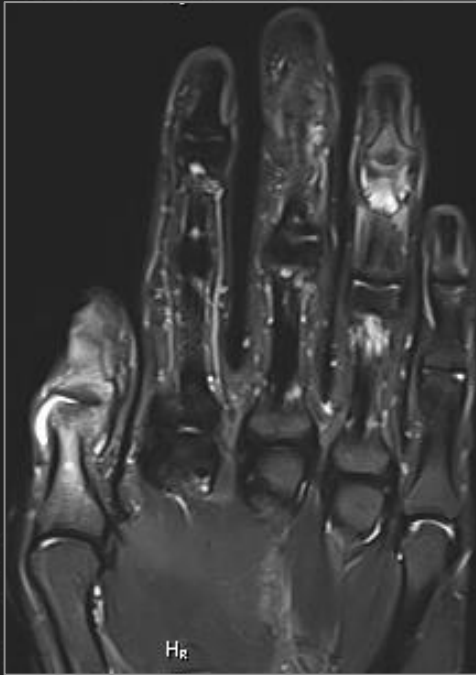


Ax PD FS  
(or STIR/TIRM or T2 FS)



CE T1 FS Ax

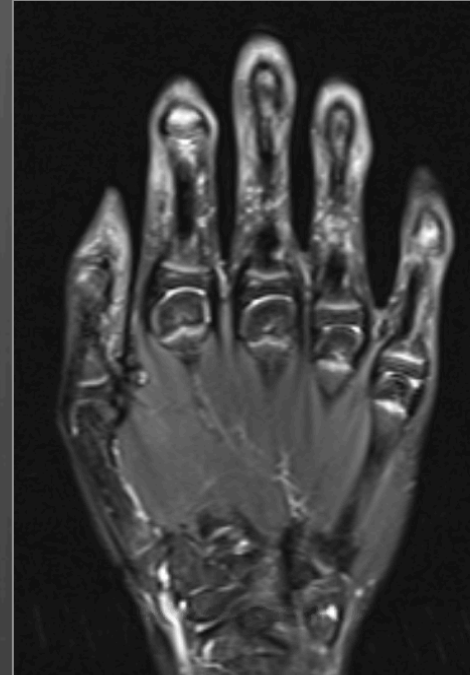
# Recommended sequences - Hand



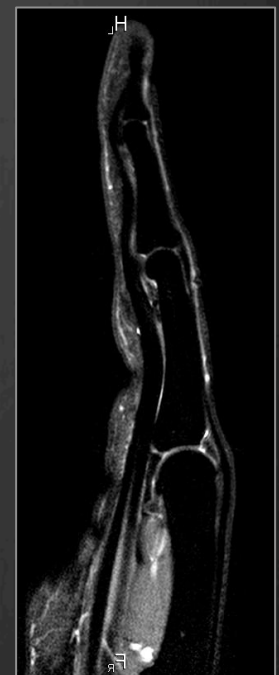
Cor STIR  
(or TIRM or T2 FS)



Cor T1w



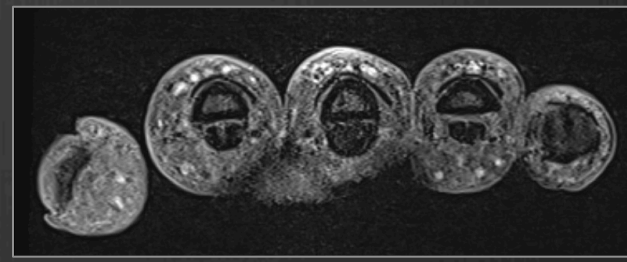
CE T1 FS Cor



Sag STIR  
(or TIRM or T2 FS)



Ax T1w



CE T1 FS Ax

# MRI protocols

Recommended Sequences	FOV (cm)	Slice thickness (mm)	TR (ms)	TE (ms)	Matrix
Cor STIR or T2 FS	8-10	3/3D <sup>#</sup>	1800	25	320x240
Cor T1	8-10	3/3D <sup>#</sup>	400	15	320x240
Ax PD FS or STIR or T2FS	8-10	3/3D <sup>#</sup>	3500	40	320x240/320x450
Ax T1	8-10	3/3D <sup>#</sup>	400	15	320x240/320x450
Sag PD FS	8-10	3/3D <sup>#</sup>	3500	40	320x240/320x450
CE T1 FS*	8-10	3/3D <sup>#</sup>	400	15	320x240/320x450

#3D sequences are performed to allow the evaluation of small (< 3mm) and/or oblique structures

\*if optimal assessment of synovitis/osteitis is needed



# Hip

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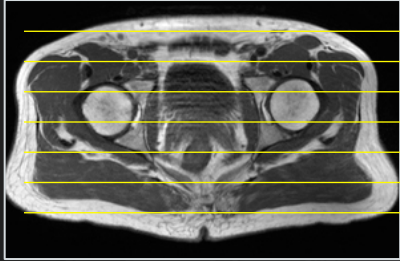


# MRI scan

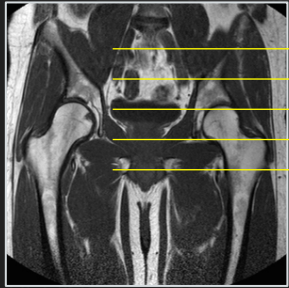
- Patient in supine position with the feet first
- Hips in 15° internal rotation
- Coils: large flexible
- Immobilisation: Tape toes to maintain position



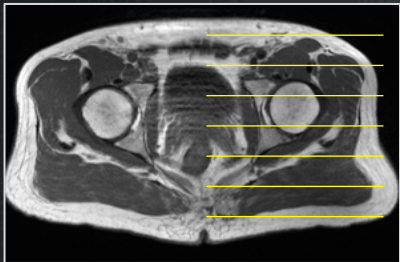
# Localizer



*Pelvis coronal plane:* large FOV (i.e., 30-40 cm) from the sacroiliac joints to the pubic symphysis



*Hip axial plane:* anterior iliac spine through lesser trochanter

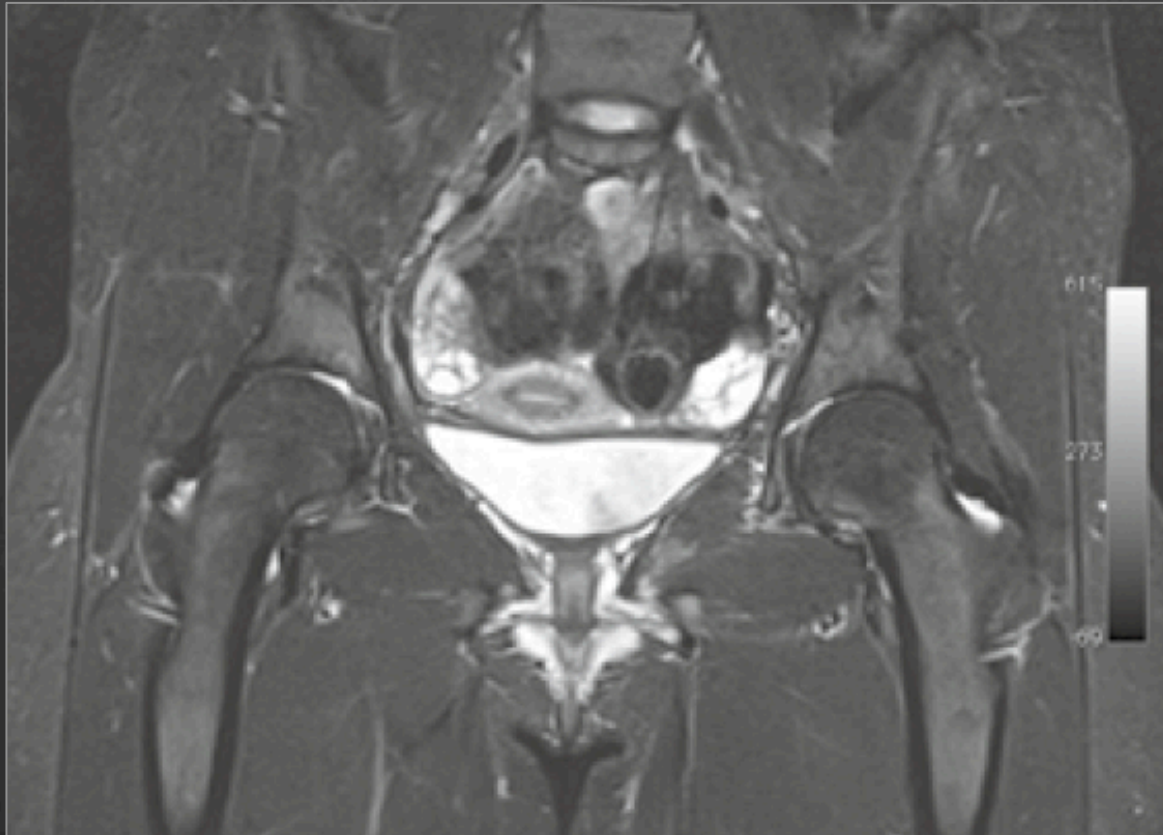


*Hip coronal plane:* skin to skin traversing anteriorly to posteriorly the acetabular columns to include the entire bony pelvis and tendon insertions



*Hip sagittal plane:* medial acetabular wall through greater trochanter

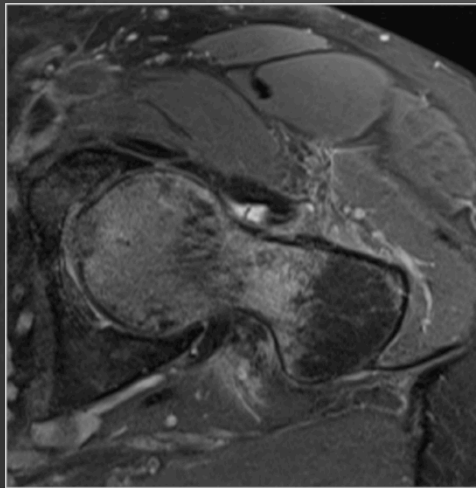
## Recommended sequences: pelvis



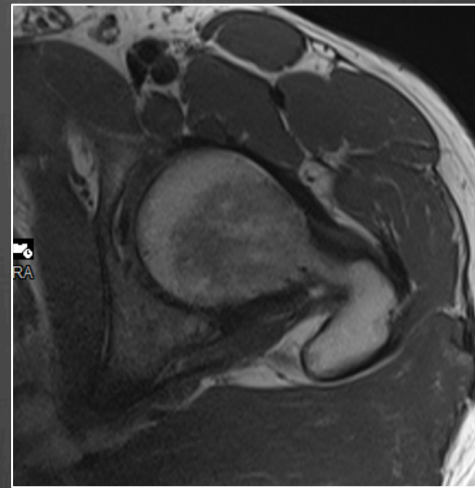
Coronal STIR  
(or T2 FS)

# Recommended sequences: Hip

Ax PD FS  
(or STIR or  
T2 FS)



Ax T1



Cor T1



Cor PD FS  
(or STIR or  
T2 FS)



# MRI protocol

Recommended Sequences	FOV (mm)	Slice thickness (mm)	TR (ms)	TE (ms)	Matrix
Pelvis Cor STIR	300	5/3D	1800	25	320X240
Hip Cor STIR	300	5/3D	1800	25	320X240
Hip Cor T1	300	5/3D	400	15	320X240
Hip Ax PD FS	300	5/3D	2000	15	320X240/384x268
Hip Ax T1	300	5/3D	400	15	320X240/384x268
Hip CE T1 FS*	300	5/3D	400	15	320X240/384x268

\*if optimal assessment of synovitis/osteitis is needed

# Knee

## MRI Protocols of the ESSR Arthritis Subcommittee



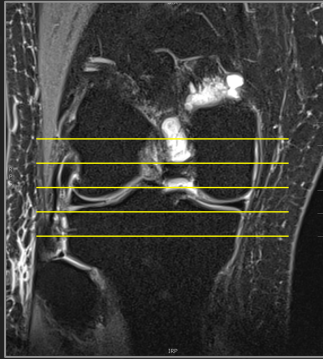
Recommendations of the ESSR Arthritis Subcommittee for the Use of Magnetic Resonance Imaging in Musculoskeletal Rheumatic Diseases. Semin Musculoskelet Radiol 2015;19:396–411



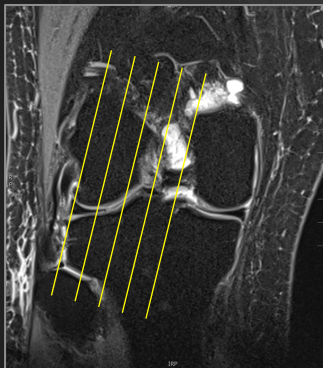
# MRI scan

- Patient in supine position with feet first
- Knee coil
- Immobilise the knee with cushions
- Three-plane localizer

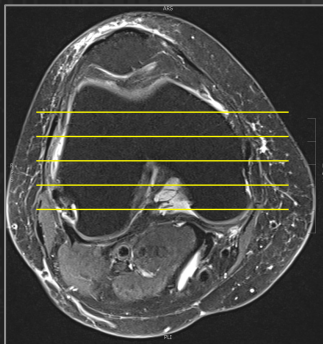
# Localizers



*Axial plane:* parallel to the knee joint line



*Sagittal plane:* parallel to the medial facet of lateral condyle

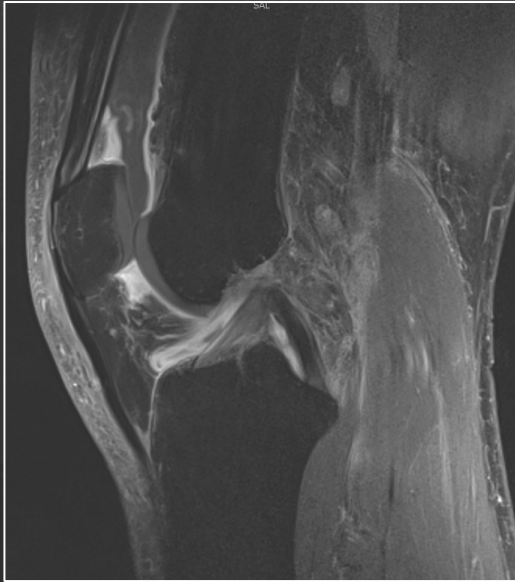


*Coronal plane:* parallel to posterior facets of the femoral condyles



# Recommended Sequences

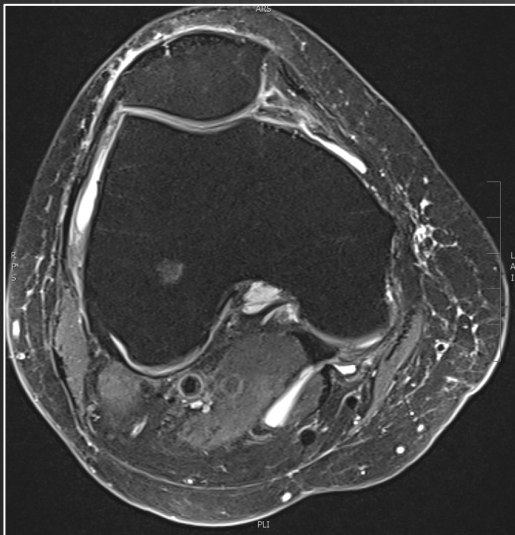
Sag PD FS



Cor PD FS



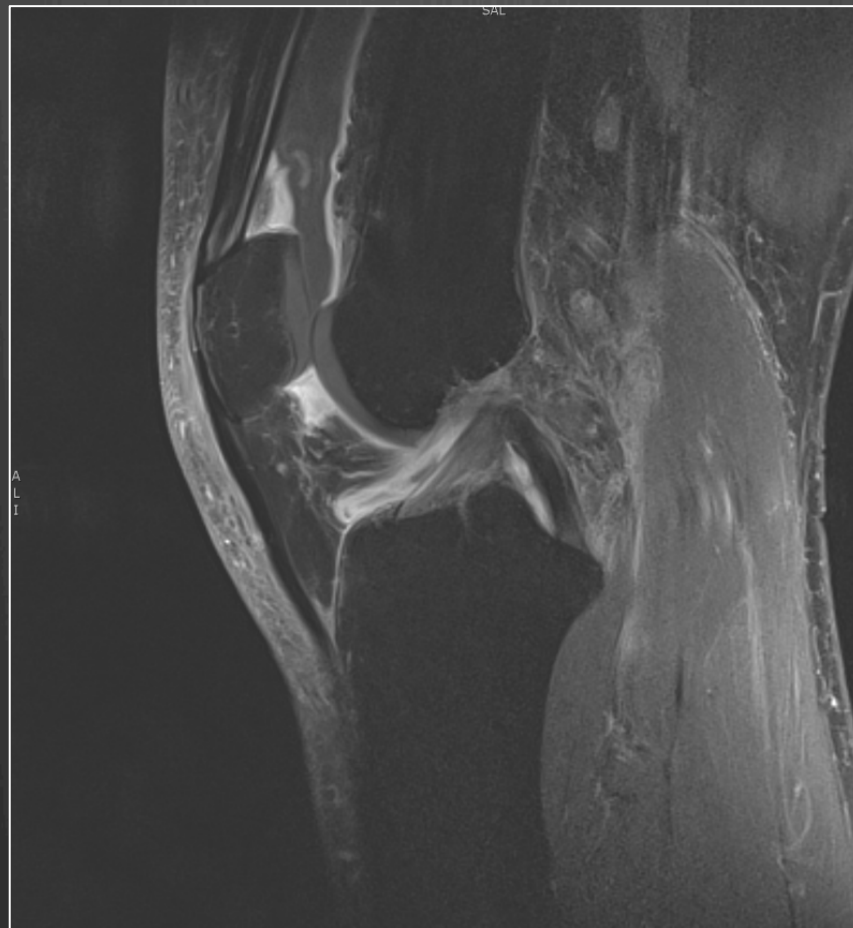
Ax PD FS



Cor T1  
(or Sag T1)



# Recommended Sequences



Sag T1 FS CE

# MRI protocol

Recommended Sequences	FOV (mm)	Slice thickness (mm)	TR (ms)	TE (ms)	Matrix
Sag PD FS	160	3	3570	39	288x384
Cor PD FS	160	3	3570	39	288x384
Ax PD FS	160	3	3570	39	288x384
Cor T1 (or Sag T1)	180	3	470	13	358x512
CE T1 FS*	180	3	470	13	358x512

\*if optimal assessment of synovitis/osteitis is needed

# Shoulder

## MRI Protocols of the ESSR Arthritis Subcommittee

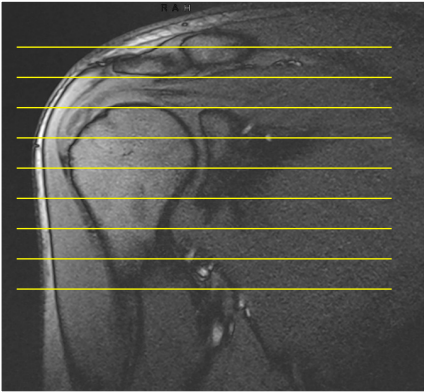


Recommendations of the ESSR Arthritis Subcommittee for the Use of Magnetic Resonance Imaging in Musculoskeletal Rheumatic Diseases. Semin Musculoskelet Radiol 2015;19:396–411

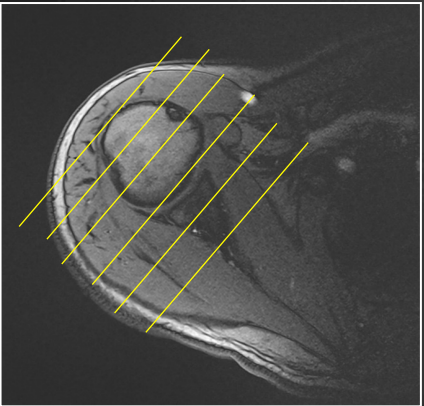
# MRI scan

- Patient in supine position
- Shoulder coil
- The arm alongside and parallel to the body in neutral to slight external rotation
- Coronal oblique images parallel to the supraspinatus tendon
- Glenohumeral and acromioclavicular joints are included

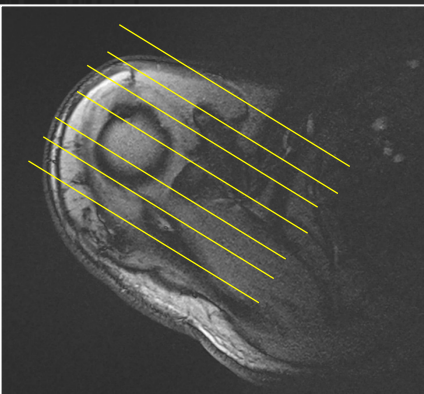
# Localizer



*Axial plane:* from the acromioclavicular joint to two slices below the inferior glenohumeral ligament



*Sagittal plane:* from the deltoid muscle to two slices medial to the glenoid

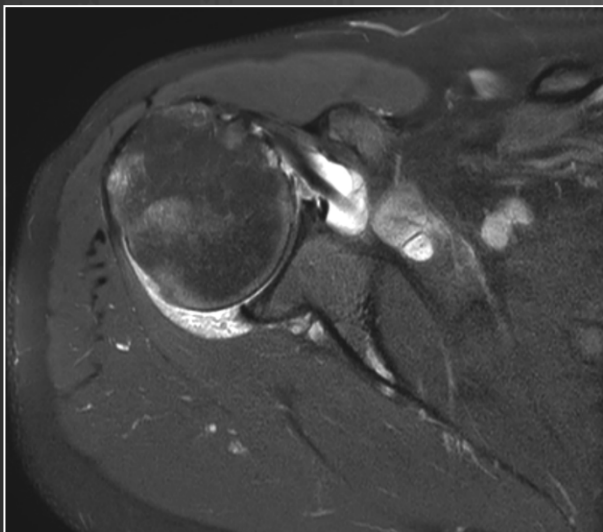


*Coronal plane:* from the anterior margin of the coracoid process to two slices posterior to the humeral head



# Recommended sequences

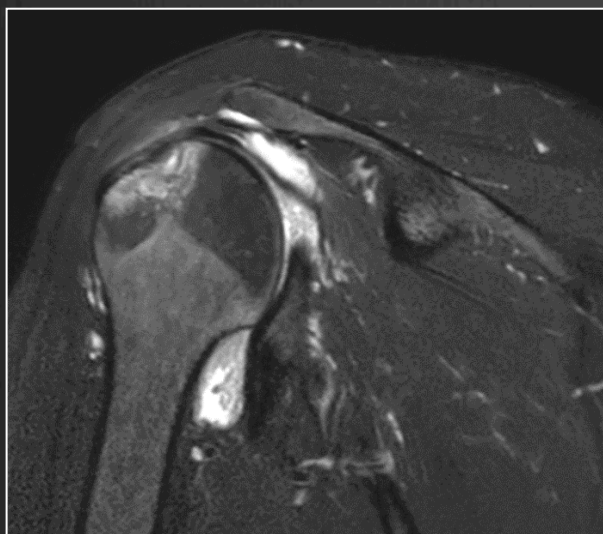
Ax PD FS



Cor T1



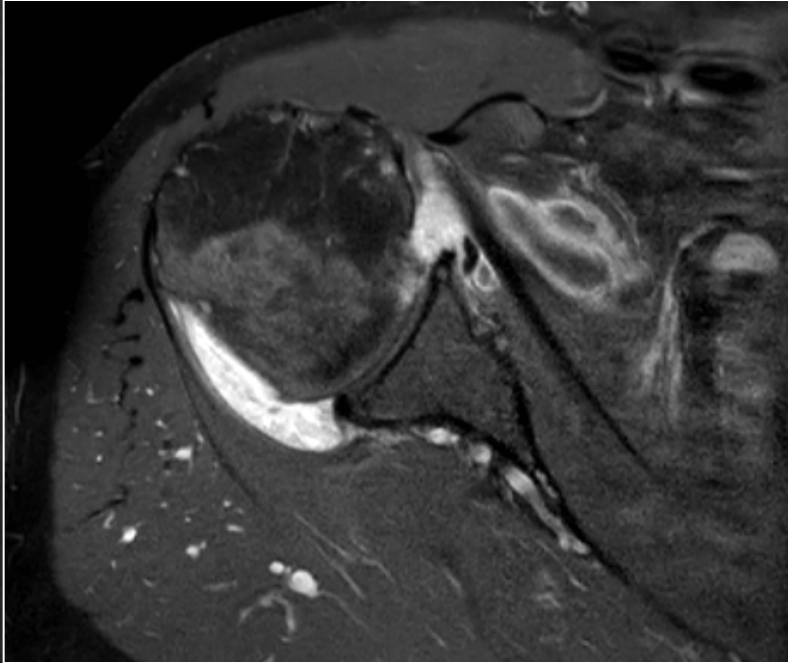
Cor T2 FS



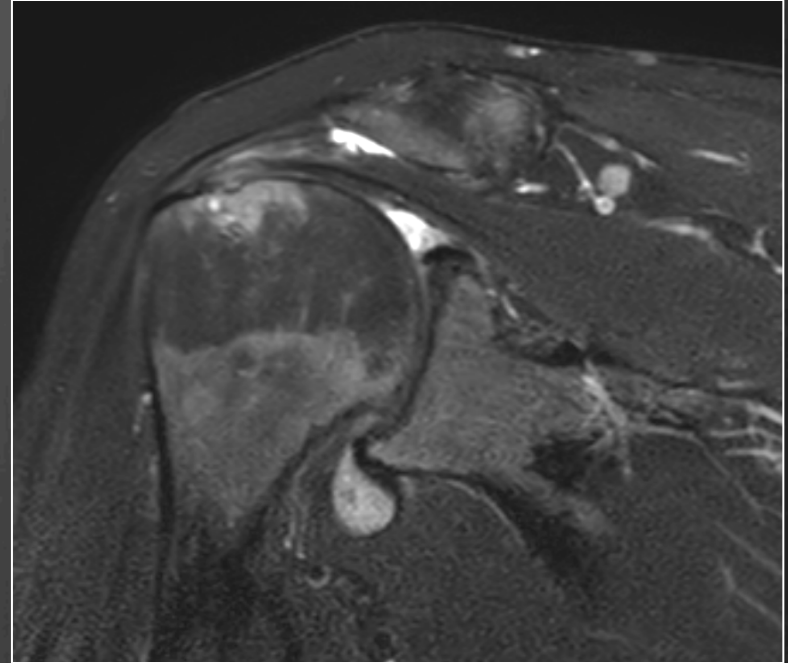
Sag T2



# Recommended sequences



CE axial T1 FS



CE cor T1 FS



# MRI protocol

	FOV (mm)	Slice (mm)	TR (ms)	TE (ms)	Matrix
Ax PD FS	180	3	2500-5000	10-30	300 x 250
Cor T1	180	3	450-650	10-20	300 x 250
Cor T2 FS	180	3	3000-5000	60-100	300 x 250
Sag T2	180	3	3000-5000	60-100	300 x 250
CE T1 FS*	180	3	450-650	10-20	300 x 250
Cor PD (optional)	180	3	3000	30	300 x 250

\*if optimal assessment of synovitis/osteitis is needed

# Sacroiliac Joints

## MRI Protocols of the ESSR Arthritis Subcommittee

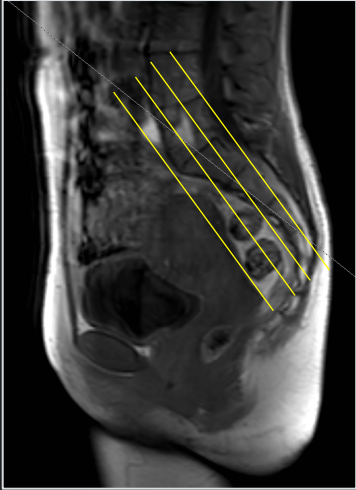


Recommendations of the ESSR Arthritis Subcommittee for the Use of Magnetic Resonance Imaging in Musculoskeletal Rheumatic Diseases. Semin Musculoskelet Radiol 2015;19:396–411

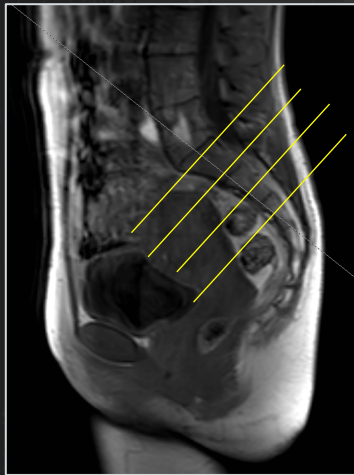
# MRI scan

- Patient in supine position with the feet first
- Spine coil or body phased array coil

# Localizer

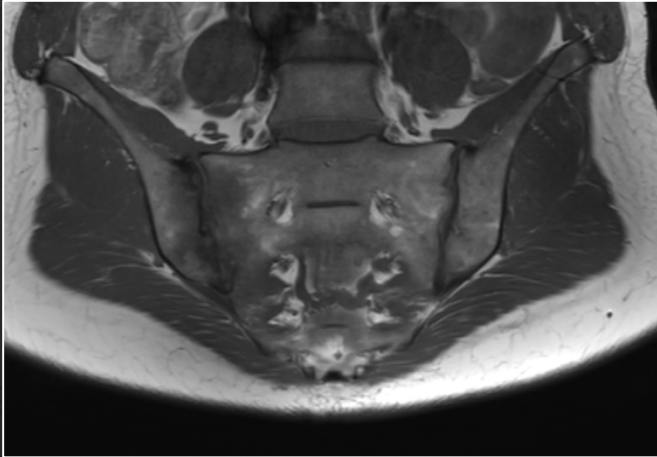


*Oblique coronal plane:* parallel to the long axis of the sacrum - tangent to the posterior surface of S2



*Oblique axial plane:* perpendicular to the coronal orientation

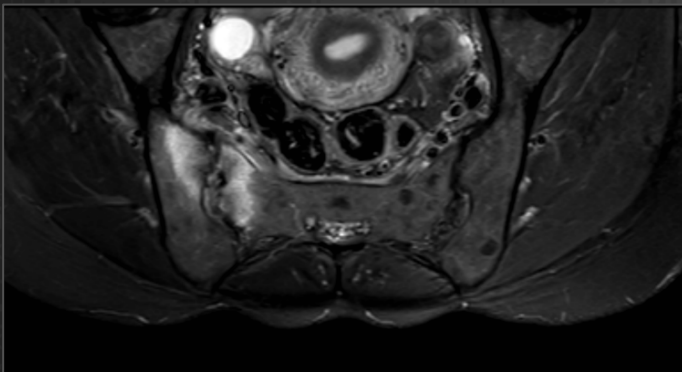
# Recommended sequences



Obl cor T1



Obl cor T1FS



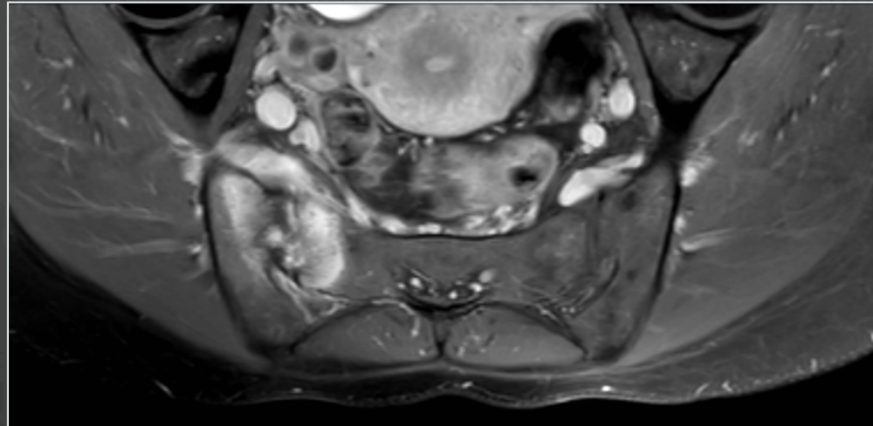
Obl axial STIR



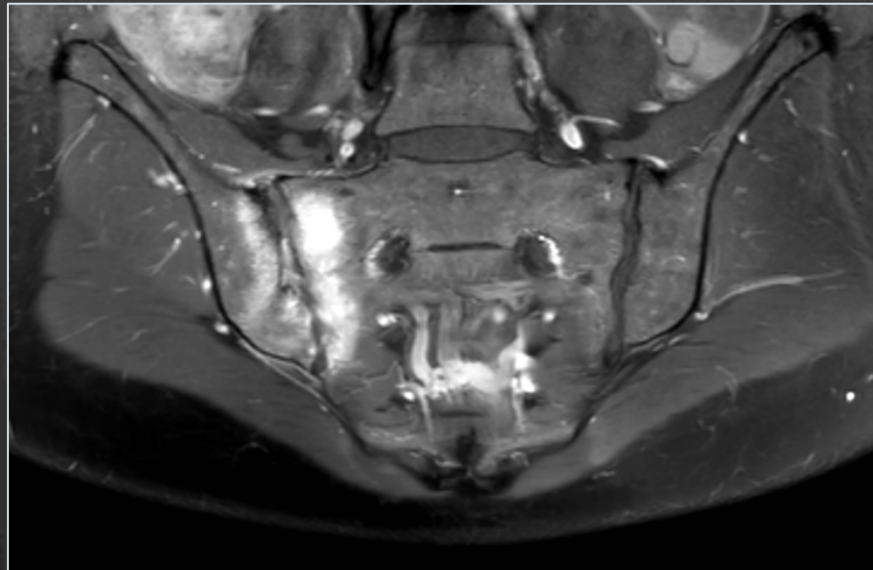
Obl cor T2 FS or STIR or TIRM or PD FS

# Recommended sequences

CE Obl ax T1 FS



CE Obl cor T1 FS



# MRI protocols

Recommended Sequences	FOV (cm)	Slice thickness (mm)	TR (ms)	TE (ms)	Matrix
Obl cor T1	24-30	3 (max 4)	400-700	8-20	>350
Obl cor T1 FS	24-30	3 (max 4)	400-700	8-20	>350
Obl cor T2 fat sat	24-30	3 (max 4)	4000-6000	60-90	>350
Obl cor STIR	24-30	3 (max 4)	3000-6000	60-90	>350
Obl axial STIR	20-25	3 (max 4)	3000-6000	60-90	>350
CE Obl cor T1 FS	24-30	3 (max 4)	400-700	8-20	>350
CE Obl axial T1FS	20-25	3 (max 4)	400-700	8-20	>350

# Spine in Spondyloarthritis

## MRI Protocols of the ESSR Arthritis Subcommittee



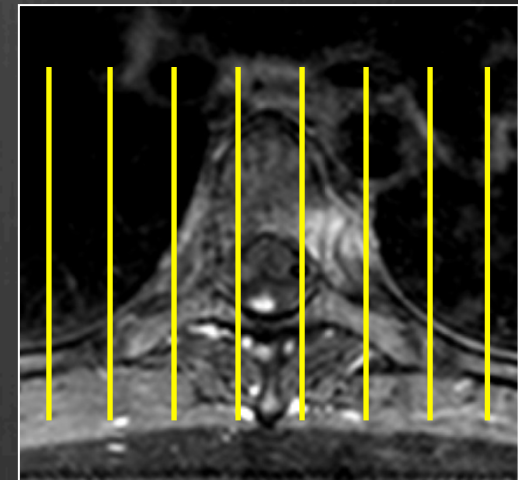
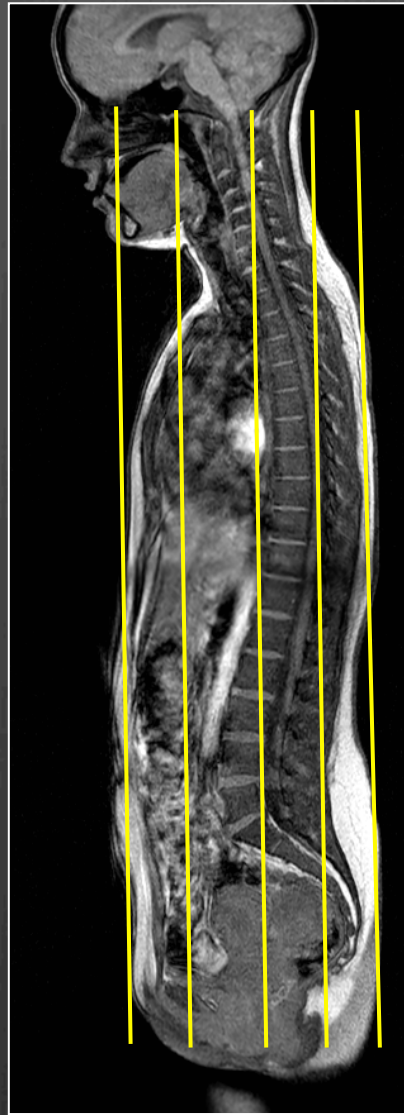
Recommendations of the ESSR Arthritis Subcommittee for the Use of Magnetic Resonance Imaging in Musculoskeletal Rheumatic Diseases. Semin Musculoskelet Radiol 2015;19:396–411



# MRI scan

- Patient in supine position
- Spine coil
- Two plane localizer
  - Frontal
  - Sagittal
- Lumbar and thoracic spine are mandatory, preferably the whole spine should be examined

# Localizer



# Recommended sequences

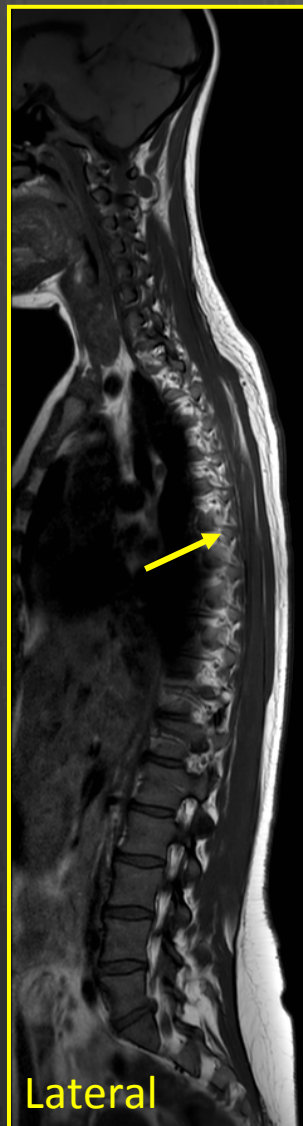


Sag T1

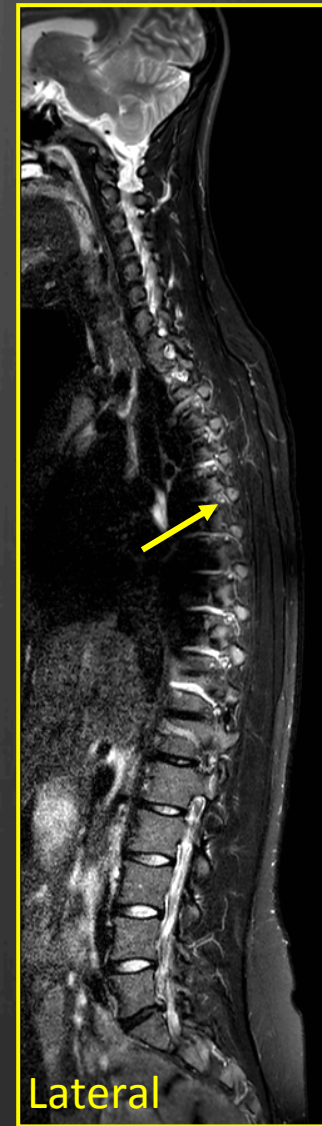


Sag STIR

# Recommended sequences



Sag T1



Sag STIR



# Optional sequence



Ax T2

# MRI Protocol

Field-of-view:	<p>Adjusted for the spine, optimizing the examined area</p> <p>Mandatory sagittal images: For the whole spine 2 or 3 spinal blocks with overlap to be fused, depending on the scanner</p> <p>Optional axial T2: FOV adjusted to the area of interest, 20-32 cm</p>
Slice thickness:	3 mm preferable (maximal 4 mm)
Interslice distance (gap)	10%

# MRI Protocol

Recommended sequences	TR (ms)	TE (ms)	TI (ms)	Matrix
Sag T1	510-550	8-20	-	424 x 300
Sag STIR	2500-6000	70-100	150 (1.5T) 180-220 (3T)	424 x 300
Ax T2 (optional)	2200-5000	90-120	-	320 x 166

# Temporomandibular Joint

## MRI Protocols of the ESSR Arthritis Subcommittee



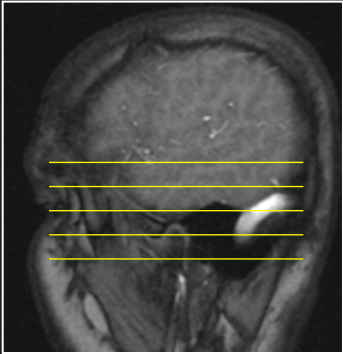
Recommendations of the ESSR Arthritis Subcommittee for the Use of Magnetic Resonance Imaging in Musculoskeletal Rheumatic Diseases. Semin Musculoskelet Radiol 2015;19:396–411



# MRI scan

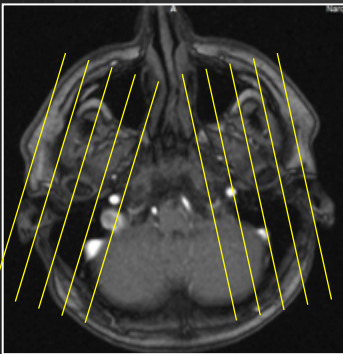
- Patient in supine position with the head first
- Head coil

# Localizer: Inflammatory disease



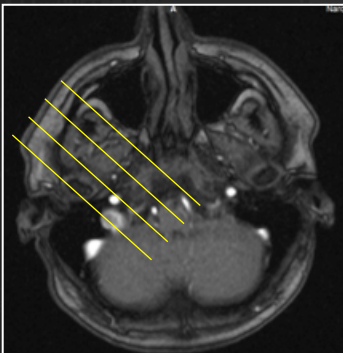
*Axial plane:* refer to the sagittal plane, orient the scan parallel to the hard palate and cover the entire TMJ from the corpus callosum up to the angle of the jaw.

If the head is tilted, the angulation has to be adjusted on the coronal plane.



*Sagittal plane:* refer to the axial plane, orient the scan perpendicular to the condyle of the mandible (i.e., of the same side that has to be examined). Check the correct positioning on the other two planes.

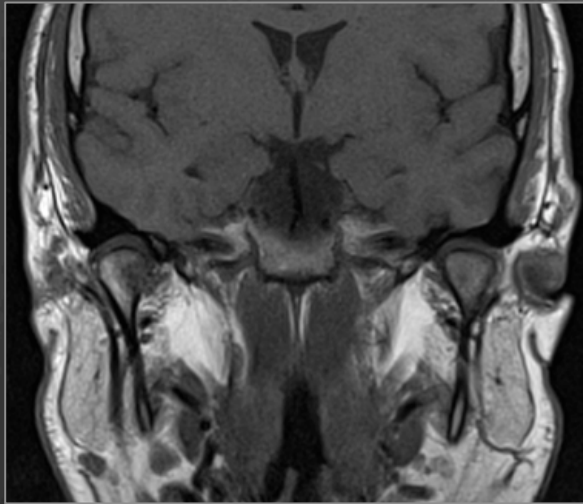
If the head is tilted, the angulation has to be adjusted on the coronal plane.



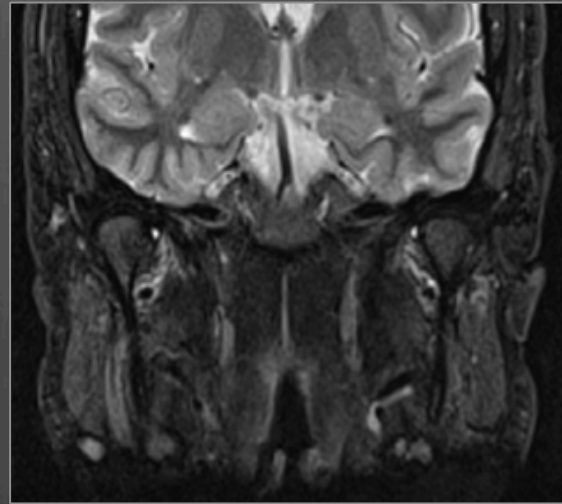
*Coronal plane:* refer to the axial plane, orient the scan parallel to the condyle of the mandible (i.e., of the same side that has to be examined). Check the correct positioning on the sagittal plane.

# Recommended Sequences: Inflammatory disease

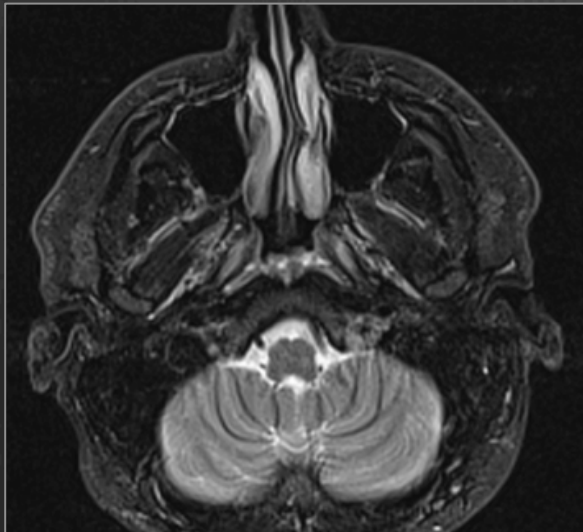
Cor T1  
(or Ax T1)



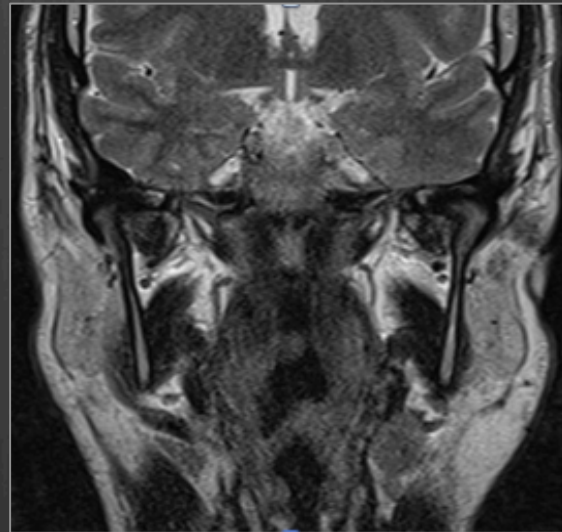
Cor T2 FS  
(or STIR  
or TIRM)



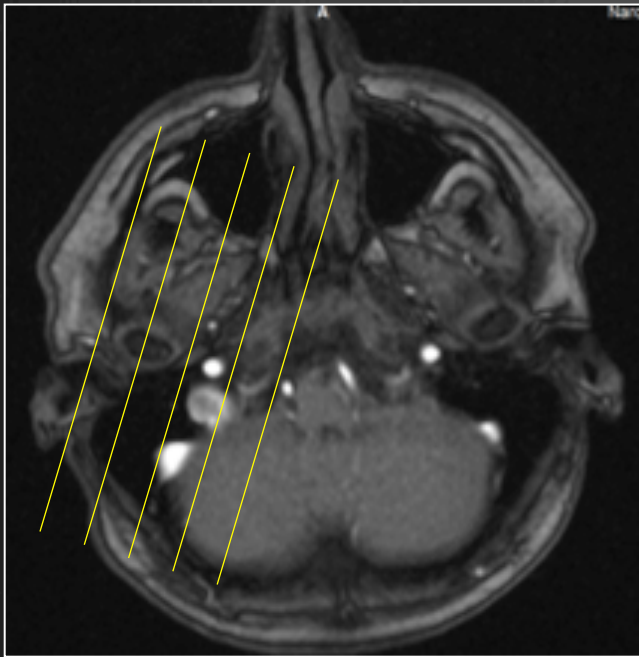
Ax T2 FS  
(or STIR  
or TIRM)



Cor T2



# Localizer: Joint derangement



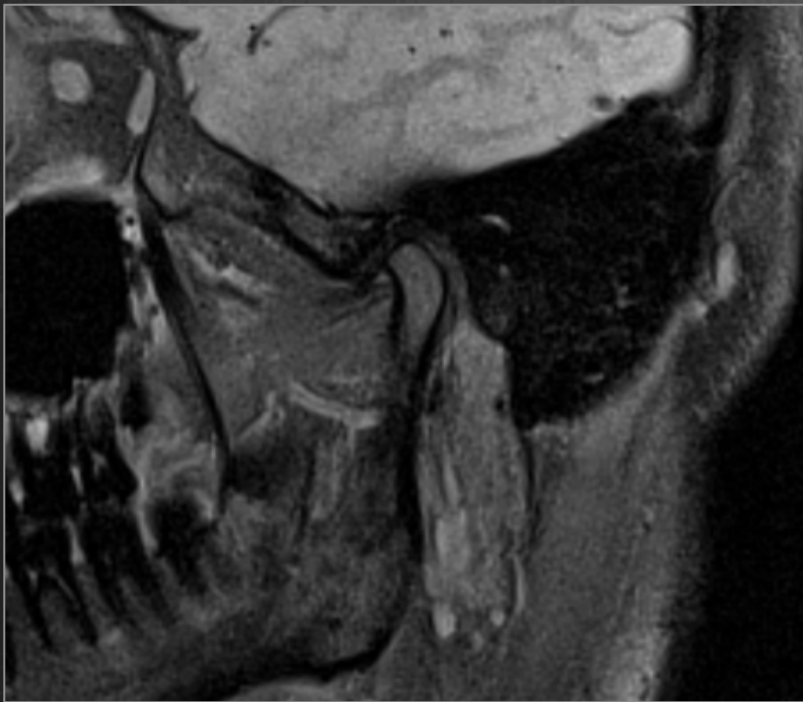
## *Sagittal oblique:*

- refer to the axial plane
- orient the scan perpendicular to the condyle of the mandible (i.e., of the same side)
- check the correct positioning on the other two planes
- the number of slices has to cover the joint from side to side

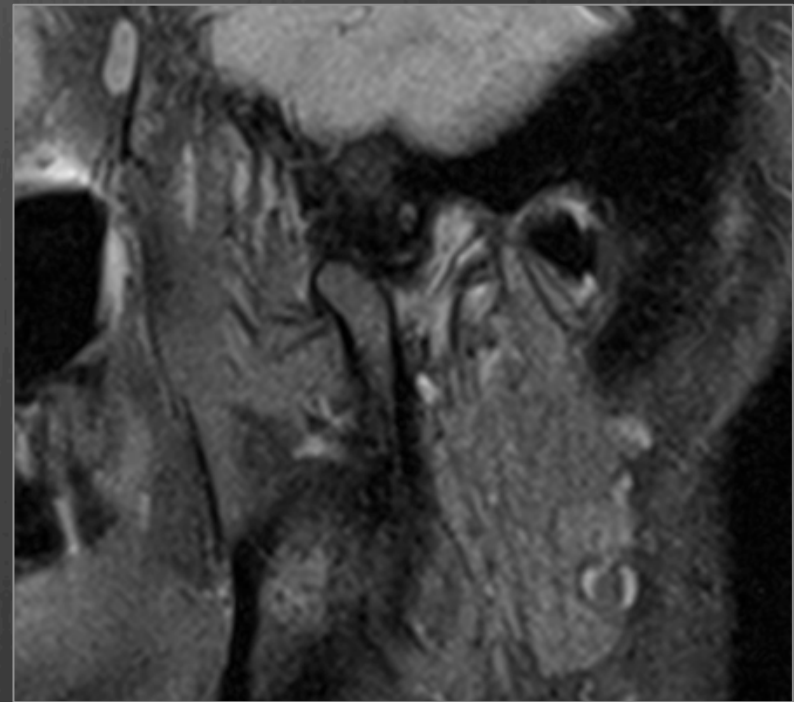
The MR scan has to be performed:

- with the mouth opened and closed
- on the right and on the left TMJ

## Recommended Sequences: Joint derangement



Sag oblique PD FS mouth closed

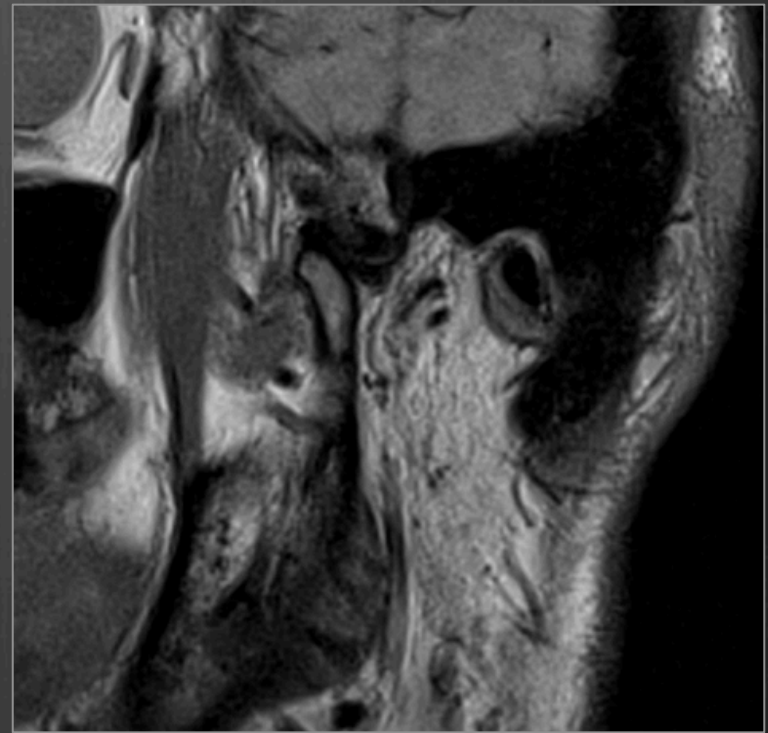


Sag oblique PD FS mouth opened

## Recommended Sequences: Joint derangement



Sag oblique PD mouth closed



Sag oblique PD mouth opened



# MRI protocols

Inflammatory disease	Recommended Sequences	FOV (mm)	Slice thickness (mm)	TR (ms)	TE (ms)	Matrix
	Cor T1	230	3	420-620	10	256x256
	Ax T2	230	5	2500-5500	90	256x256
	Cor T2 FS	230	3	2500-5000	100	256x256
	Cor T2	230	3	2200-3200	100	256x256
	CE T1 FS (for synovitis and/or osteitis)	140	2.5	420-620	10	256x256
	PD FS oblique mouth closed & opened	140	2.5	2200-3200	24	256x256
	PD oblique mouth closed & opened	140	2.5	2200-3200	24	256x256
Joint derangement						

# Whole Body MRI for Chronic Recurrent Multifocal Osteomyelitis

MRI Protocols of the  
ESSR Arthritis Subcommittee



Recommendations of the ESSR Arthritis Subcommittee for the Use of Magnetic Resonance Imaging in Musculoskeletal Rheumatic Diseases. Semin Musculoskelet Radiol 2015;19:396–411



# MRI scan

- Patient in supine position with the head first
- Hands either under the pelvis (preferred for immobilisation) or over the abdomen
- Elbows often outside the field of view
- Multiple coils – to ensure coverage
- Coil coverage: Head to feet
- 3-5 stations depending on age and height of the patient

# Recommended sequences



T1



STIR



TIRM

# MRI protocol

Recommended Sequences	FOV (mm)	Slice thickness (mm)	TR (ms)	TE (ms)	Matrix
T1	550	3	300-600	8	640x640
STIR	550	3	3000-4000	70	512x512
TIRM	550	2	4000-6120	60	512 x 512

# Acronyms

Ax= axial

CE= contrast enhanced

Cor= coronal

CRMO= Chronic Recurrent Multifocal Osteomyelitis

FOV= field of view

FS= fat suppressed

Obl= Oblique

PD= proton density

Sag= sagittal

STIR= short tau inversion recovery

TE= echo time (ms)

TIRM= turbo inversion recovery magnitude

TMJ= Temporomandibular joint

TR= repetition time (ms)

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