Instructions for MR Technicians:

The musculoskeletal fellow will protocol all musculoskeletal MR cases in advance. Please check the protocol on the request sheet carefully before starting the case. If "routine protocol" is specified, please use the attached protocols. Any deviations from the routine protocol will be indicated on the sheet in sufficient detail for you to understand the substitution. If you can not perform the routine protocol or if you have questions, please phone or page the musculoskeletal fellow covering your institution. The number at the UCSD bone board is 32147 and the number of the Thornton bone board is 76780. The list of fellows covering the services and their pager numbers will be available through the chief technician. Please page the musculoskeletal fellow if a "wet reading" is requested. If you can not reach the fellow, please page the attending radiologist covering bone (check the schedule to know who to page).

Study quality is the responsibility of the technician. Please put the initials of the technician in the comments area on the MR so we know who to contact if the examination needs to be repeated or if we need to speak to the technician. Fat suppression is particularly problematic and is often nonuniform. Please check the fat suppression and if it is not adequate, repeat the study.

Be sure to have the patient complete the history sheet as part of their examination preparation. The bone questionnaire needs to be completed so we have adequate clinical information.

Liberal use of skin markers in encouraged over the specific site of symptoms or over any palpable mass. The markers should be applied lightly, without deforming the skin. A light dab of Vaseline fulfills all the functions of a marker without causing skin distortion!

Specific question about cartilage (any joint)

Evaluate OCD
R/O bony bar
Chondromalacia

Eliminate the T1 SE coronal
Eliminate the FSE axial and replace with 1 of the following, depending on indication:

Plane	Sequence	TR/TE	FOV	Matrix	Slice / Gap	NEX	Freq
coronal OCD, bony bar	3D SPGR 30 degree fat sat	45/9	14	196	1-2 mm/0	2	SI NP
axial patella	3D SPGR 30 degree fat sat	45/9	14	196	1-2 mm/0	2	SI NP
sagittal AVN, graft	3D SPGR 30 degree fat sat	45/9	14	196	1-2 mm/0	2	SI NP

UCSD Tumors/Masses

This protocol is only a generic recommendation. Each case needs to be evaluated in conjunction with the history, physical examination, and other imaging.

Mark the area of palpable abnormality with a pellet, applied loosely to the skin! Avoid compressing the lesion with the markers or the imaging coil. Image the tumor in a nondependent position if the patient is in pain (e.g., position patient with posterior mass prone).

Large tumors need to be imaged with the body coil. Use a large FOV, contrast-sensitive sequence (FMPIR or T2-w FSE with fat-sat) to localize the lesion and determine its full extent. For marrow assessment, a large FOV sagittal and/or coronal T1-w image should be performed. Depending on the size of the lesion, the body coil or a surface coil can be utilized for the rest of the study. Large tumors (>10-12 cm) typically require the body coil. Moderate size tumors (5-10 cm) should have the initial sequences done with the body coil and the later sequences done with a surface coil, using a smaller FOV to study the lesion in detail. Smaller tumors of the distal extremities can be imaged using a surface coil for the entire study. Masses located anteriorly or posteriorly are better evaluated with sagittal images, whereas masses located medially or laterally are better evaluated with coronal images. Staging requires PD and T2-w sequences in the axial plane in all cases.

Fat-suppressed post-GD-DTPA images are obtained if necessary.

Plane	Sequence	TR/TE	FOV	Matrix	Slice / Gap	NEX
Mark	*the*	*skin*	*and*	*find*	*the*	*lesion*
sagittal or coronal	FMPIR	2500/30 TI 150	3-4x tumor size	128	5/1.5	1
Check	*the*	*adjacent*	*bone*	*marrow*		
sagittal or coronal	SE	600/20	2-3x tumor	128	4/1	1
?Surface	*coil*	*Stage*	*lesion*	*with*	*smaller*	*FOV*
axial PDT2	FSE fat-sat	3000/19 3000/90	usually smaller	192	4/1	2
axial	SE	600/20	same as FSE axial	192	4/1	2
Is	*Gd-DTPA*	*needed?*	*If*	*yes*		
axial	SE fat-sat	600/20	same as FSE axial	192	4/1	2

UCSD R/O Occult fracture
(this is a limited charge protocol)

The occult fracture protocol is reserved for patients unable to weight-bear, with normal or equivocal radiographs. Almost all requests are for the pelvis or hip. The study is done during normal working hours.

These screening studies should be monitored and a wet reading should be provided. Use the larger FOV fast IR and T1-w SE to find the areas of osseous abnormality. Study abnormal areas with a smaller FOV T1-w sequence to define the extent of the fracture line.

R/O Pelvis/Hip fracture

Plane	Sequence	TR/TE	FOV	Matrix	Slice / Gap	NEX
Coronal	FMPIR	2500/30 TI 150	36	128	5/1.5	1
Coronal	SE	600/20	24	192	4/1	1 NP
Axial	SE	600/20	36	192	4/1	1 NP

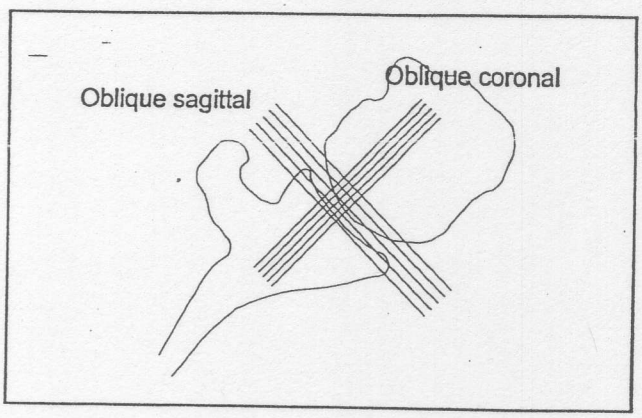
R/O Knee fracture

Plane	Sequence	TR/TE	FOV	Matrix	Slice / Gap	NEX
Sagittal	FMPIR	2500/30 TI 150	18	128	5/1.5	1
Sagittal	SE	600/20	14	192	4/1	1
Coronal	SE	600/20	14	192	4/1	1 NP

For other body parts (rarely requested), adjust plane of imaging and FOV as appropriate.

UCSD Shoulder

Coil: Shoulder
Positioning: Supine, external rotation of shoulder



R/O Rotator cuff tear
R/O Internal derangement
R/O Impingement
Shoulder pain

Technicians – Please film your axial image with selected slice angles.

Plane	Sequence	TR/TE	FOV	Matrix	Slice / Gap	NEX	Freq
coronal	FMPIR	2850/30 TI 150	16-18	128	5/1.5	1	SI
axial	MPGR fat sat	700/15 30 degree	14	192	3/1	1	RL
oblique coronal	double-echo SE	2000/20 2000/80	14	192	4/1	1	Obl
oblique sagittal	FSE fat-sat	3000/60	14	192	4/1	2	Obl
oblique sagittal	SE	600/13	14	128	4/1	2	Obl

Most current = July, 02.

UCSD Elbow

Coil: **Flex-wrap**
Positioning: **Supine, elbow extended and supinated at side**

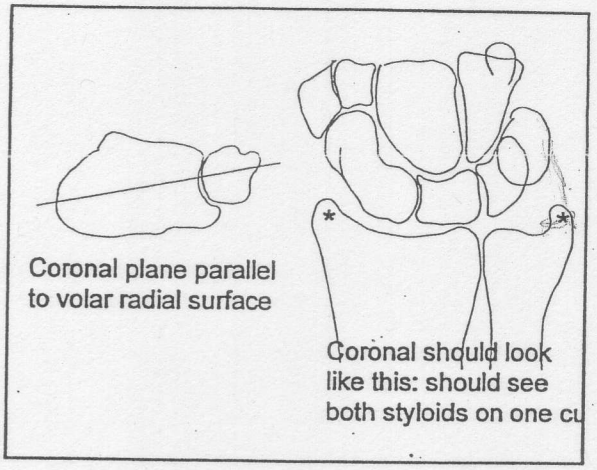
The elbow is difficult to position comfortably. We prefer the supine position with the elbow by the side and the elbow fully supinated. Prone positioning, with the elbow placed above the head, is an alternate position that brings the elbow to the isocenter but the elbow is distorted and this position is less comfortable for the patient and they tend to move.

Do the axial sequence first to select the correct planes for the coronal and sagittal. The coronal sequence should be along the axis of the epicondyles and the sagittal perpendicular to the epicondylar axis. The ligaments are difficult to visualize if the coronal is not done correctly. Go along the plane of the anterior humeral condyles at the level of the medial epicondyle on the axial images to get the right coronal plane. Images should be filmed (reversed if necessary) so that the humerus is superior, as shown in the picture above.

Plane	Sequence	TR/TE	FOV	Matrix	Slice / Gap	NEX	Freq
Coronal	FMPIR	2800/30 TI 150	16	128	4/1	1	SI NP
Axial	FSE PD	3000/20	10-12	256	4/1	2	RL NP
Axial	FSE T2 fat sat	3000/96	10-12	256	4/1	2	RL NP
Coronal	FSE PD	3000/20	10-12	256	4/1	2	RL NP
Coronal	FSE T2 fat sat	3000/96	10-12	256	4/1	2	RL NP
Sagittal	SE	600/12	10-12	256	4/1	1	RL NP

UCSD Wrist

Coil: Quad Wrist
Positioning: Supine, neutral wrist



The wrist should be comfortably immobilized to the side of the patient. Build up the height of the wrist to the isocenter. Try to avoid excessive pronation of the wrist. Do the axial plane first to select the optimum plane for the coronal sequence. The coronal images should be obtained from the radial styloid to the ulnar styloid. The ideal coronal plane is often oblique (parallel to volar radial cortex) rather than true coronal. If the coronal sequence is not well positioned, it is very difficult to evaluate the TFCC and the intercarpal ligaments.

Images should be filmed (reversed if necessary) so that the proximal part of the joint is at the bottom of the image (like the drawing above).

R/O TFCC tear
R/O ligament tear
R/O ganglion
Bony abnormality

Plane	Sequence	TR/TE	FOV	Matrix	Slice / Gap	NEX
axial	T2-w FSE fat-sat	3800/102	8	192	3/1	2
sagittal	SE	450/20	8	128	3/1	2
coronal	double-echo FSE	3850/17 3850/102	8	192	3/1	2 NP
Coronal	FMPIR	2800/30 TI 150	16	128	4/1	2

UCSD Pelvis/Hip

Coil: **Body**
Positioning: **Supine**

R/O AVN
Pelvic Pain

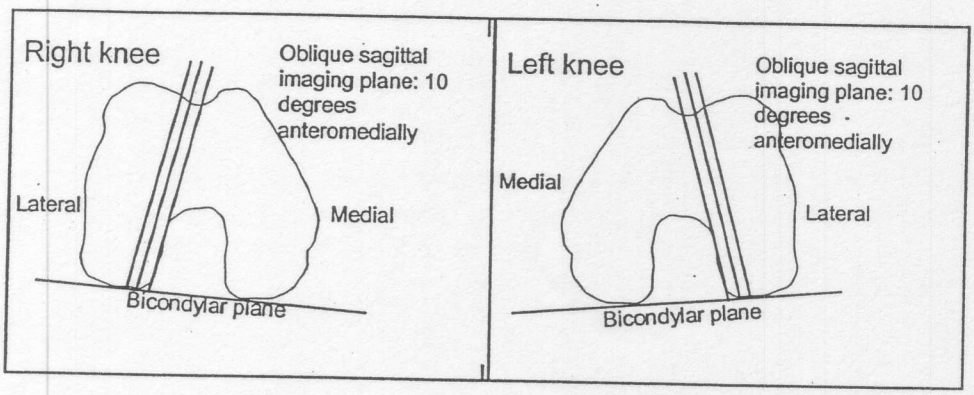
Plane	Sequence	TR/TE	FOV	Matrix	Slice / Gap	NEX	Freq
Coronal	FMPIR	3000/25 TI 150	32-36	128	4/1	2	SI NP
Coronal	SE	600/12	32-36	192	4/1	2	SI NP
Coronal	FSE	3000/102	32-36	192	4/1	2	SI NP
Sagittal	SE	850/12	24	192	3/1	1	SI

UCSD Knee

Coil: **Extremity**
Positioning: **Supine, slight external rotation and flexion of knee**

R/O internal derangement
R/O meniscus tear
R/O ligament tear

The axial images must include the entire patella and femorotibial joint. The oblique sagittal is angled **10 degrees** anteromedially relative to the bicondylar line. This plane is parallel to the inner edge of the lateral femoral condyle or the outer anterolateral edge of the femur. **Do not use too steep an angle!** Film the axial image with the selected slice angles.

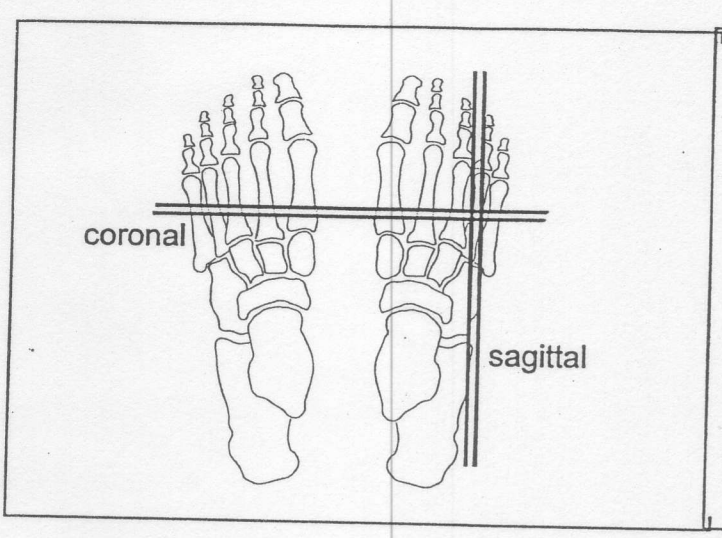


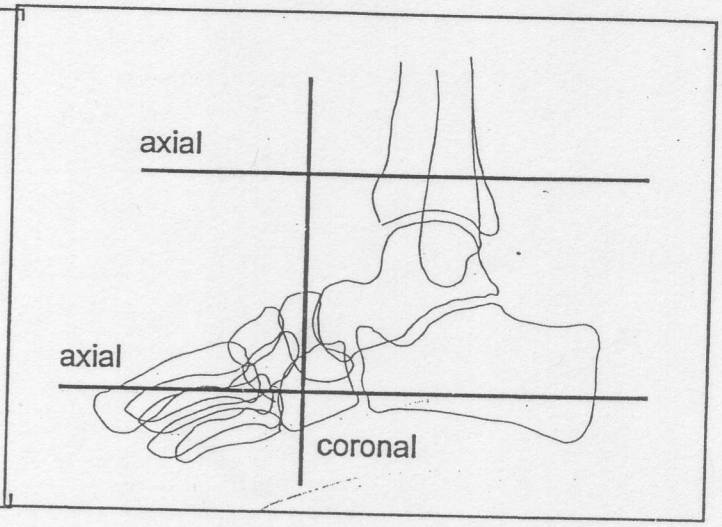
Plane	Sequence	TR/TE	FOV	Matrix	Slice / Gap	NEX	Freq
(1) sagittal localizer	FMPIR	2500/25 TI 150 Go up if want better	18	128	5/2.5	1	SI NP
(2) axial	FSE fat-sat	3700/20	14	256	4/1	2	NP
(4) oblique sagittal	double-echo SE	2000/20 2000/80	14	192	4/1	1	Obl NP
(3) coronal	FSE fat-sat	3950/20	14	192	4/1	2	SI
coronal	SE	600/20	14	192	4/1	1	SI

Film magnified meniscal windows of sagittal PD-w and coronal T1-w sequences.

UCSD Ankle and Foot

It is difficult to write a good routine protocol for the ankle and foot because the proper selection of planes and FOV varies, depending on the clinical indication.
These are the conventions we use for the planes of the ankle and foot.





Coil: **Extremity (One foot only!!)**
Positioning: **Prone**
Comments: **Wrap saturation pad around ankle/foot**

Ankle Ankle ligaments
Ankle tendons

Plane	Sequence	TR/TE	FOV	Matrix	Slice / Gap	NEX
axial PD T2	double-echo FSE fat sat	3500/19 3500/90	10-12	128	3/1 or 4/1	2
sagittal T1	SE	600/20	12	128	3/1	1
sagittal PD T2	double-echo FSE fat-sat TSE	3500/20 3500/90	12	192	3/1	2
coronal PD Tse fs	FSE fat-sat	3000/20	10-12	192	3/1	2

Foot

Osteomyelitis/Abscess (usually foot)
Foot masses/tumors

Plane	Sequence	TR/TE	FOV	Matrix	Slice / Gap	NEX
sagittal	FMPIR	2500/30 TI 150	14	128	4/1	1
axial (plantar)	double-echo SE	2000/20 2000/80	12	128	3/1	2 NP
coronal	FSE fat-sat	3000/19 3000/96	12	128	3/1	2 NP
coronal	SE	600/20	12	128	3/1	2

Image only one foot at 3 mm slices whenever possible!!
For bilateral feet (only do this is there is a question about both feet, not routinely), use 24 cm FOV for the coronal and axial images. Switch to the head coil if both feet are necessary.

UCSD Tumors/Masses

This protocol is only a generic recommendation. Each case needs to be evaluated in conjunction with the history, physical examination, and other imaging.

Mark the area of palpable abnormality with a pellet applied loosely to the skin! A dap of Vaseline is even better and will not distort the skin. Avoid compressing the lesion with the markers or the imaging coil. Image the tumor in a nondependent position if the patient is in pain (e.g.. position patient with posterior mass prone).

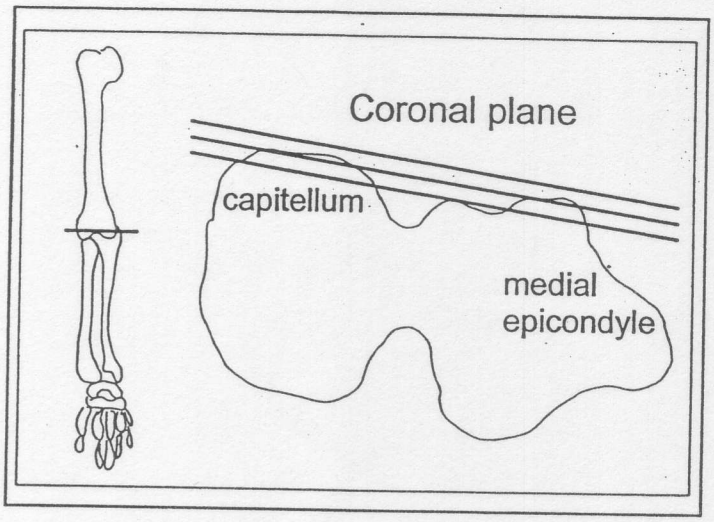
Large tumors need to be imaged with the body coil. Use a large FOV, contrast-sensitive sequence (FMPIR or T2-w FSE with fat-sat) to localize the lesion and determine its full extent. For marrow assessment, a large FOV sagittal and/or coronal T1-w image should be performed. Depending on the size of the lesion, the body coil or a surface coil can be utilized for the rest of the study. Large tumors (>10-12 cm) typically require the body coil. Moderate size tumors (5-10 cm) should have the initial sequences done with the body coil and the later sequences done with a surface coil, using a smaller FOV to study the lesion in detail. Smaller tumors of the distal extremities can be imaged using a surface coil for the entire study. Masses located anteriorly or posteriorly are better evaluated with sagittal images, whereas masses located medially or laterally are better evaluated with coronal images.

Fat-suppressed post-GD-DTPA images are obtained if necessary.

Plane	Sequence	TR/TE	FOV	Matrix	Slice / Gap	NEX
Mark	*the*	*skin*	*and*	*find*	*the*	*lesion*
sagittal or coronal	FMPIR	2500/30 TI 150	3-4x tumor size	128	5/1.5	1
Check	*the*	*adjacent*	*bone*	marrow		
sagittal	SE	600/20	2-3x tumor	128	4/1	1
?Surface	*coil*	*Stage*	*lesion*	*with*	*smaller*	*FOV*
axial	PD/T2 FSE fat-sat	3000/19 3000/90	2x tumor	192	4/1	2
axial	SE	600/20	2x tumor	192	4/1	2
Is	*Gd-DTPA*	*needed?*	*If*	*yes*		
axial	SE fat-sat	600/20	same as FSE axial	192	4/1	2
sagittal or coronal	SE fat-sat	600/20	same as FSE axial	192	4/1	2

UCSD Elbow

Coil: **5" surface**
Positioning: **Supine, elbow extended at side**



The elbow is difficult to position comfortably and the study is often degraded by motion artifact. Try to position the elbow as close to the isocenter as possible. Prone positioning, with the elbow placed above the head, is an alternate position but is less comfortable for the patient.

The coronal sequence should be along the axis of the epicondyles. Use the axial sequence to set up the plane for the coronal sequence. The ligaments are difficult to visualize if the coronal is not well positioned. Go along the plane of the anterior humeral condyles on the axial images to get the right coronal plane.

Images should be filmed (reversed if necessary) so that the proximal part of the joint is at the top of the image (like the drawing above).

Plane	Sequence	TR/TE	FOV	Matrix	Slice / Gap	NEX	Freq
Coronal	FMPIR	2800/30 TI 150	16	128	4/1	2	SI NP
Axial	Double-echo FSE	3000/17 3000/102	12	192	4/1	2	RL NP
Coronal	Double-echo FSE	3000/17 3000/102	12	192	3/1	2	RL NP
Sagittal	SE	600/12	12	128	3/1	2	RL NP

UCSD Elbow

Coil: Flex-wrap
Positioning: Supine, elbow extended and supinated at side

The elbow is difficult to position comfortably. We prefer the supine position with the elbow by the side and the elbow fully supinated. Prone positioning, with the elbow placed above the head, is an alternate position that brings the elbow to the isocenter but the elbow is distorted and this position is less comfortable for the patient and they tend to move.

Do the axial sequence first to select the correct planes for the coronal and sagittal. The coronal sequence should be along the axis of the epicondyles and the sagittal perpendicular to the epicondylar axis. The ligaments are difficult to visualize if the coronal is not done correctly. Go along the plane of the anterior humeral condyles at the level of the medial epicondyle on the axial images to get the right coronal plane. Images should be filmed (reversed if necessary) so that the humerus is superior, as shown in the picture above.

Plane	Sequence	TR/TE	FOV	Matrix	Slice / Gap	NEX	Freq
Coronal	FMPIR	2800/30 TI 150	16	128	4/1	1	SI NP
Axial	FSE PD	3000/20	10-12	256	4/1	2	RL NP
Axial	FSE T2 fat sat	3000/96	10-12	256	4/1	2	RL NP
Coronal	FSE PD	3000/20	10-12	256	4/1	2	RL NP
Coronal	FSE T2 fat sat	3000/96	10-12	256	4/1	2	RL NP
Sagittal	SE	600/12	10-12	256	4/1	1	RL NP

UCSD Wrist

Coil: Quad Wrist Coil
Positioning: Supine, neutral wrist

The wrist should be comfortably immobilized to the side of the patient. Build up the height of the wrist to the isocenter. Try to avoid excessive pronation of the wrist. Do the axial plane first to select the optimum plane for the coronal sequence. The coronal images should be obtained from the radial styloid to the ulnar styloid. If the coronal sequence is not well selected, it is difficult to evaluate the TFCC and the intercarpal ligaments.

Images should be filmed (reversed if necessary) so that the proximal part of the joint is at the bottom of the image.

Plane	Sequence	TR/TE	FOV	Matrix	Slice / Gap	NEX
coronal localizer	FMPIR	2800/30 TI 140	14	128	4/1	2
axial	FSE PD	2500/20	8	256	3/1	2 NP
axial	FSE T2 fat sat	2500/96	8	256	3/1	2 NP
coronal	FSE PD	2500/20	8	256	3/1	2 NP
coronal	FSE T2 fat sat	2500/96	8	256	3/1	2 NP
coronal	MPGR	450/15 30 degree	8	192	.6 - .8 mm	2
sagittal	SE	450/20	8	256	4/1	1

UCSD Pelvis/Hip

Coil: **Body**
Positioning: **Supine**

R/O AVN
Pelvic Pain
All questions regarding GI and GU tract go to the Body MR service!

The pelvis examination is straightforward. We do not want to use fat suppression on these large FOV studies due to universal fat sat failure around the edges. The coronal images need to include the whole pelvis, including the sacrum. The axial images need to include the entire pelvis from the top of the sacrum to the bottom of the ischial tuberosities.

Plane	Sequence	TR/TE	FOV	Matrix	Slice / Gap	NEX	Freq
Coronal	FMPIR	3000/25 TI 140	36	128	5/1	2	SI NP
Coronal	SE	600/20	32-36	256	5/1	1	SI NP
~~Coronal~~	~~FSE T2~~ no fatsat	~~3000/102~~	~~32-36~~	~~256~~	~~4/1~~	~~2~~	~~SI~~ NP
Axial of whole pelvis	FSE no fatsat	3000/102	32-36	256	5/1	2	SI
Sagittal both hips	SE	850/12	24	192	3/1	1	SI

UCSD Knee

Coil: Extremity
Positioning: **Supine, slight external rotation and flexion of knee**

R/O internal derangement
R/O meniscus tear
R/O ligament tear

The axial images must include the entire patella and femorotibial joint. The oblique sagittal is angled **10 degrees** anteromedially relative to the bicondylar line. This plane is parallel to the outer anterolateral edge of the femur. **Do not use too steep an angle!** Film the axial image with the selected slice angles.

Plane	Sequence	TR/TE	FOV	Matrix	Slice / Gap	NEX	Freq
sagittal localizer	FMPIR	2500/25 TI 150	18	128	5/2.5	1	SI NP
axial	FSE fat-sat	2500/20	14	256	4/1	2	NP
oblique sagittal	double-echo SE	2000/20 2000/80	14	192	4/1	1	Obl NP
coronal	FSE fat-sat	3950/20	14	192	4/1	2	SI
coronal	SE	600/20	14	192	4/1	1	SI

Specific question about cartilage (any joint)

Evaluate OCD
R/O bony bar
Chondromalacia

Add 1 of the following, the specific plane depend on indication. This is a lengthy sequence so it should only be added if there is a specific issue requiring excellent cartilage visualization. I always use this for questions about bony bars or following osteochondral grafting. It is good for OCD, though MRA is usually better. The cartilage sequence is not necessary for routine cases of chondromalacia.

Plane	Sequence	TR/TE	FOV	Matrix	Slice / Gap	NEX	Freq
coronal OCD, bony bar	3D SPGR 30 degree fat sat	45/9	14	196	1-2 mm/0	2	SI NP
axial patella	3D SPGR 30 degree fat sat	45/9	14	196	1-2 mm/0	2	SI NP
sagittal AVN, graft	3D SPGR 30 degree fat sat	45/9	14	196	1-2 mm/0	2	SI NP

UCSD Hindfoot and Forefoot

It is difficult to image the hindfoot and the forefoot together and do a good study. Please look at the indication and try to do either a hindfoot exam or a forefoot exam whenever possible. If there is a question limited to the ankle region, do the hindfoot protocol. The hindfoot includes the heel to the tarsometatarsal junction. The forefoot includes the metatarsals and phalanges. These are the conventions we use for the planes of the ankle and foot. If we need to image both feet, they must be done separately.
For the forefoot exam, the axial slices should be angled to be as close as possible to the plane of the metatarsals. Fat suppression around the heel and toes is a problem with the Siemens magnets.

Coil: **Extremity (One foot only!!)**
Positioning: **Supine**
Comments: **Wrap saturation pad around ankle/foot**

Hindfoot

The hindfoot examination needs to include the entire ankle and extend to the tarsometatarsal joint.

Plane	Sequence	TR/TE	FOV	Matrix	Slice / Gap	NEX
axial	PD FSE	2500/20	10-12	256	3/1 or 4/1	2
axial	T2 FSE fat sat	2500/90	10-12	192	3/1 or 4/1	2
sagittal	SE	600/20	10-12	192	3/1	1
sagittal	T2 FSE fat-sat	2500/90	10-12	192	3/1	2
coronal	PD FSE	2500/20	10-12	192	3/1	2
coronal	T2 FSE fat sat	2500/20	10-12	192	3/1	2

Forefoot

The forefoot protocol is the same. The study needs to extend from the tarsometatarsal joint to the tips of the toes.

Shoulder (Instability and Postoperative)

R/O labral tear
Evaluate instability
History of dislocation
Rotator cuff surgery

Patients being evaluated specifically for instability should all be examined following intraarticular injection of Gd-DTPA. Discuss the case with the referring physician and schedule for an MRA rather than a conventional arthrogram. The patient should be scheduled for an arthrogram in the main department one hour prior to the MR study. Postoperative cases are also best evaluated with intraarticular contrast.

Plane	Sequence	TR/TE	FOV	Matrix	Slice / Gap	NEX
oblique coronal	FSE T2	3000/80	14	192	4/1	2
oblique coronal	T1 fat sat	600/20	14	192	4/1	1
oblique sagittal	T1 fat sat	600/20	14	192	4/1	1
axial	T1 fat sat	600/20	14	192	3/1	1

sagittal or coronal	SE fat-sat	600/20	same as FSE axial	192	4/1	2

UCSD R/O Occult fracture (this is a limited charge protocol)

The occult fracture protocol is reserved for patients unable to weight-bear, with normal or equivocal radiographs. Almost all requests are for the pelvis or hip. The study is done during normal working hours.

These screening studies should be monitored and a wet reading should be provided. Use the larger FOV fast IR and T1-w SE to find the areas of osseous abnormality. Study abnormal areas with a smaller FOV T1-w sequence to define the extent of the fracture line.

R/O Pelvis/Hip fracture

Plane	Sequence	TR/TE	FOV	Matrix	Slice / Gap	NEX
Coronal	FMPIR	2500/30 TI 150	36	128	5/1.5	1
Coronal	SE	600/20	24	192	4/1	1 NP
Axial	SE	600/20	36	192	4/1	1 NP

R/O Knee fracture

Plane	Sequence	TR/TE	FOV	Matrix	Slice / Gap	NEX
Sagittal	FMPIR	2500/30 TI 150	18	128	5/1.5	1
Sagittal	SE	600/20	14	192	4/1	1
Coronal	SE	600/20	14	192	4/1	1 NP

For other body parts (rarely requested), adjust plane of imaging and FOV as appropriate.