Zimmer® PSI Knee

MRI Protocol

803.125 rev G

Contents

Zimmer PSI Knee MRI Protocol

The *Zimmer* PSI Knee MRI protocol is applicable for the largest MRI scanner manufacturers in North America, i.e. GE, Siemens, Philips, Hitachi and Toshiba. Scanning instructions that are common to all manufacturers and Dedicated Knee coilsare provided in Sections 1 and 2 while Section 3 contains specific settings for hip, knee and ankle scans that are required for each manufacturer. Sections 4 and 5 contain instructions for MRI sample and DICOM export. Sample images to verify image quality are provided in Section 6.

Note: Zimmer only qualifies the medical imaging scanners in terms of their ability to comply with the *Zimmer PSI Knee MRI Protocol*. It is the responsibility of the prescribing surgeon to ensure that the medical imaging center complies with applicable radiological standards and laws.

The following MRI protocol is intended for scanners of 1.5T and higher preferably for the following MRI manufacturers: GE, Siemens, Philips, Toshiba and Hitachi. This protocol is also applicable to Dedicated Knee Transmit/Receive Coil (T/R Coil) for GE, Siemens and Toshiba. Images received at Zimmer CAS shall not be lossy compressed.

1 Patient positioning

The patient should be positioned on the scanning bed (couch) according to the following criteria:

- Position the patient supine and feet first (FFS) on the scanning bed.

- Position the knee as much as possible at isocenter, by moving the whole imaged leg towards the center of the bed, if possible.

- Position the patient's knee in the center of the knee coil; a flex or torso Receive-only coil may also be used.

- Acquired slices must include complete distal femoral bone structure including medial and lateral epicondyles.

- A scan with motion artifacts will be rejected. Use ankle immobilizer, sand bags, and/or straps for patient comfort and to minimize patient movement. Please refer to Cheat Sheet in **Appendix A** for more patient positioning tips.

- Place the knee in a neutral axial rotation as much as possible (Figure 1).

Figure 1: Knee in a neutral axial rotation

- If posterior condyles are not parallel with FOV's medial-lateral direction after patient positioning efforts, the Field of View may be rotated up to a **maximum of 30°**.
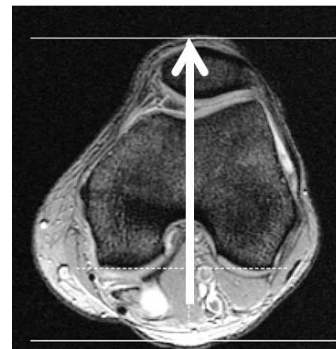
> ⚠️ **IMPORTANT NOTICE:**
> **The patient cannot move during or between the scans, except upon T/R-Coil removal.**
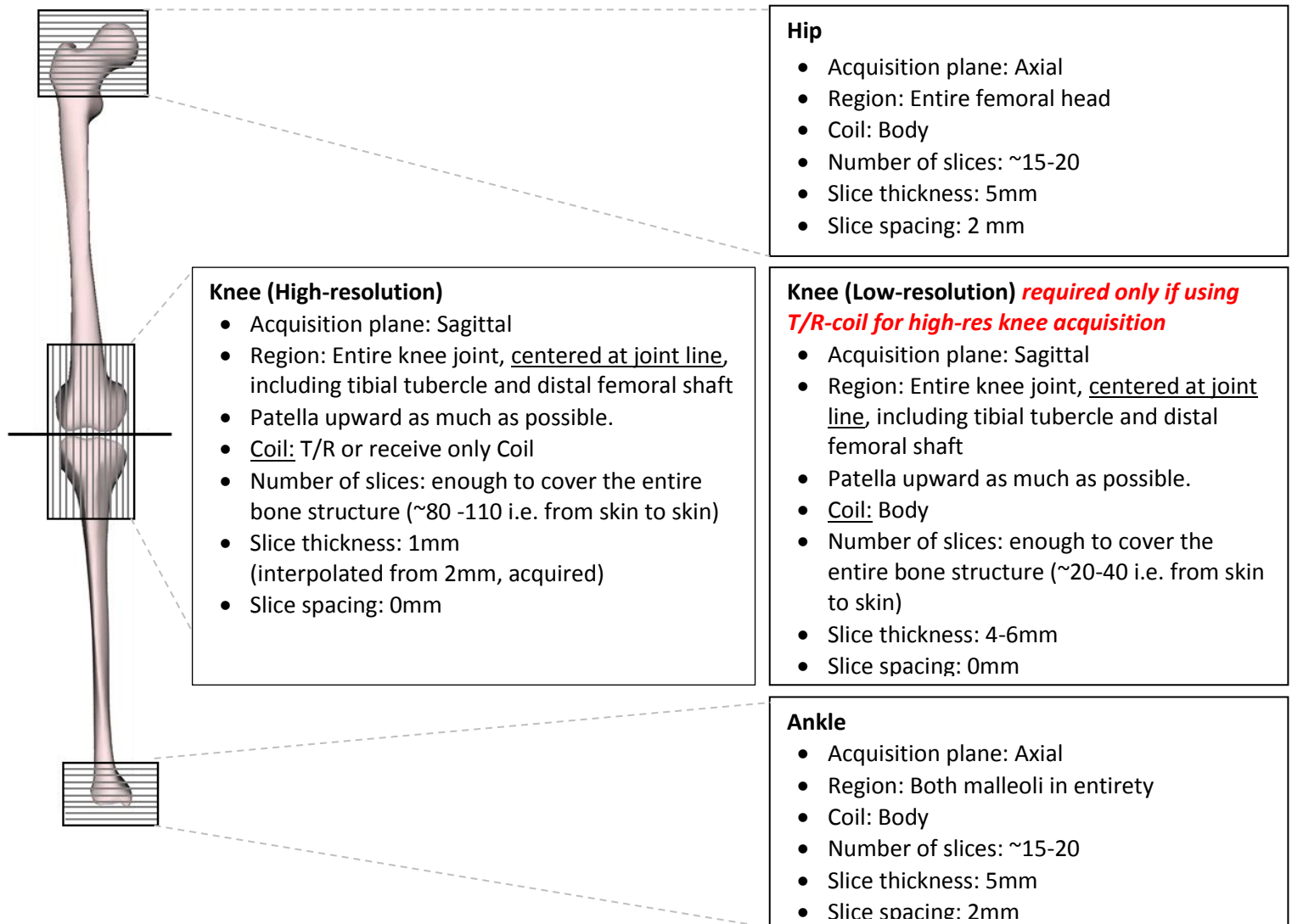
2   Protocol summary

- See the following pages for manufacturer-specific settings.
- All low res series must be within the same study.

2.1   Knee Receive only Coil instructions

- Apart from localizers/scouts, the MRI scanning protocol consists in three image series: hip, knee, and ankle. **No resetting/re-landmarking allowed in between series**.
- No patient movement allowed in between series.

2.2   Knee T/R-Coil instructions

- Apart from localizers/scouts, the MRI scanning protocol consists in four image series: high-resolution knee, followed by hip, knee, and ankle in low-resolution.
- First, landmark knee at the joint line and scan the knee joint with the T/R-coil.
- Remove the knee coil and reposition the patient on the table.
- Re-landmark at the knee joint and scan hip, knee and ankle low resolution series. **No resetting/re-landmarking allowed in between low-resolution series**.

Hip
- Acquisition plane: Axial
- Region: Entire femoral head
- Coil: Body
- Number of slices: ~15-20
- Slice thickness: 5mm
- Slice spacing: 2 mm

Knee (High-resolution)
- Acquisition plane: Sagittal
- Region: Entire knee joint, centered at joint line, including tibial tubercle and distal femoral shaft
- Patella upward as much as possible.
- Coil: T/R or receive only Coil
- Number of slices: enough to cover the entire bone structure (~80 -110 i.e. from skin to skin)
- Slice thickness: 1mm (interpolated from 2mm, acquired)
- Slice spacing: 0mm

Knee (Low-resolution) *required only if using T/R-coil for high-res knee acquisition*
- Acquisition plane: Sagittal
- Region: Entire knee joint, centered at joint line, including tibial tubercle and distal femoral shaft
- Patella upward as much as possible.
- Coil: Body
- Number of slices: enough to cover the entire bone structure (~20-40 i.e. from skin to skin)
- Slice thickness: 4-6mm
- Slice spacing: 0mm

Ankle
- Acquisition plane: Axial
- Region: Both malleoli in entirety
- Coil: Body
- Number of slices: ~15-20
- Slice thickness: 5mm
- Slice spacing: 2mm

3 Manufacturer Specific Parameters

3.1 General Electric Protocol

Parameters listed in table below are recommended for 1.5 Tesla systems. Different magnetic field strengths or scanner settings may require different parameters for adequate image quality, such as TR, TE and Bandwidth.

Tab	Parameters	Knee (High-resolution)	Knee (Low-resolution, needed if T/R-coil is used for High-resolution)	Hip	Ankle
Patient position	Coil	T/R (for example: Quad extremity coil) and receive only Coil (for example: GE Precision Eight Knee Array Coil, GP Flex, Long Bone Lower)	Body	Body	Body
	Patient position	Supine	Supine	Supine	Supine
	Patient entry	Feet First	Feet first	Feet first	Feet first
Imaging Options	Plane	Sagittal	Sagittal	Axial	Axial
	Mode	3D	3D	2D	2D
	Gradient mode	Whole	Whole	Whole	Whole
	Pulse sequence	Fast TOF SPGR	Fast TOF SPGR	FSE-XL	FSE-XL
	Imaging option	Zip 512, Zip 2 ONLY	None	No phase wrap	No phase wrap
Additional parameters	Fat saturation	ON	ON	OFF	OFF
Scan timing	TE	Min_full	Min_full	Min_full	Min_full
	TR	Approx. range: 10-20	Approx. range: 10-20	400 – 700	400 – 700
	Flip Angle	12	12	90	90
	Bandwidth (kHz)	19.2	19.2	19.2	19.2
Acquisition timing	Frequency	256 **(with Zip 512 ON)**	256	256	256
	Phase FOV (%)	85-100	85-100	85-100	85-100
	NEX	1-2	1-2	1	1
Scanning range	FOV (cm)	20	26	34	24
	Slice thickness(mm)	2 **(with Zip 2 ON)**	4-6	5	5
	Slice spacing (mm)	None	None	2	2
	Number of slices	~80-120	~20-40	~15 – 20	~15 – 20

3.2 Siemens Protocol

Parameters listed in table below are recommended for 1.5 Tesla systems. Different magnetic field strengths may require different parameters for adequate image quality, such as TR, TE and Bandwidth.

Parameters	Knee (High-resolution)	Knee (Low-resolution, needed if T/R-coil is used for High-resolution)	Hip	Ankle
Table position	ISO			
Coil	T/R (for example: CP Extremity, 15-ch knee, Symphony) and receive only Coil (for example: 8-ch Knee, Body Matrix, CP Body Array Flex, Large Flex)	Body	Body	Body
Pulse sequence	3D spoiled gradient echo VIBE or FLASH sequence	3D spoiled gradient echo VIBE or FLASH sequence	2D T1 TSE (FSE-XL)	2D T1 TSE (FSE-XL)
Acquisition plane	Sagittal	Sagittal	Axial	Axial
Number of slices	~80 – 110	~20-40	~15 – 20	~15 – 20
FOV read	200	260	340	240
FOV Phase (%)	80	80	85	85
TR	17-20 or minimum	20	400-700	400-700
TE	4-10	4-10	9-20	9-20
Averages	1 or 2	1 or 2	1	1
Filter	Distortion correction (2D)	Distortion correction (2D)	-	-
Fat Sat	Fat Sat On	Fat Sat On	Fat Sat Off	Fat Sat Off
Fat Suppr	WE normal, FAT SAT	WE normal, FAT SAT	None	None
Water Suppr	None	None	None	None
Flip Angle	12-25	12-25	90	90
Slice thickness (mm)	1 (with interpolation ON)	4-6	5	5
Slice spacing (mm)	0	0	2	2
Resolution	256 x 256 (Interpolated to 512x512)	256x256	256x256	256x256
Bandwidth	100	100	500	500

Siemens Syngo MR A series

(2004A, A30, A35 and etc…)

- Special Instructions -

Please note that on the affected systems (Syngo A series such as 2004A, Syngo A30 or A35 etc…) it is necessary to use the laser light localizer only once to mark the location of the knee.

The table movements to scan the Hip and Ankle must be programmed in the sequence or the table must be moved manually without re-activating the laser light localizer between series.

To perform the laser option:

1. Laser light on the ankle, and scan the desired images.
2. Move the table to the knee.
3. Ensure that the "Scan at current TP" is selected on the "System Card/Tab" of the sequence.
4. Scan the desired images
5. Move the table to the hip.
6. Ensure that the "Scan at current TP" is selected on the "System Card/Tab" of the sequence.
7. Scan the desired images.

For the SIEMENS systems mentioned above, do not rotate Field of View. **No OBLIQUE images** - only true axial and sagittal images are accepted.

3.3   Philips Protocol

Parameters listed in table below are recommended for 1.5 Tesla systems. Different magnetic field strengths may require different parameters for adequate image quality, such as TR, TE and Bandwidth.

Parameter	Knee (High-resolution)	Knee (Low-resolution, needed if T/R-coil is used for High-resolution)	Hip	Ankle
Coil	Receive only (for example: SENSE Knee, dS Knee 8/16ch, dS Flex, Knee/Foot)	Body	Body	Body
Pulse sequence	3D WATSc	3D WATSc	2D T1 TSE Hip	2D T1 TSE Ankle
Slice orientation	Sagittal	Sagittal	Transverse	Transverse
Field of view (mm)	FH = 200 AP = 200	FH = 260 AP = 260	FH = 340 AP = 340	FH = 240 AP = 240
Slice thickness (mm)	1 (overcontiguous slices = YES)	4-6	5	5
Slice gap (mm)	0	0	2	2
Number of slices	~80 – 110 (whole knee)	~20 – 40	~15 – 20	~15 – 20
Acquired voxel size	FH = 0.78 AP = 0.78	FH = 0.78 AP = 0.78	AP = 1.33 RL = 1.33	AP = 0.94 RL = 0.94
Reconstructed voxel size	FH = 0.39 AP = 0.39	FH = 0.39 AP = 0.39	AP = 1.33 RL = 1.33	AP = 0.94 RL = 0.94
Reconstruction matrix	512	256	256	256
Scan mode	3D	3D	2D	2D
Technique	FFE	FFE	TSE	TSE
Contrast enhancement	T1	T1	T1	T1
TR	17.2	10-20	400 – 700	400 – 700
TE	Shortest in-phase (4-10)	Shortest in-phase (~20)	Shortest in-phase (~20)	Shortest in-phase (~20)
Flip Angle	25	10-25	90	90
Fat suppression	ProSet	ProSet	None	None
Pulse Type	121	n/a	n/a	n/a
NSA	2	1	1	1

3.4   Toshiba Protocol

Parameters listed in table below are recommended for 1.5 Tesla systems. Different magnetic field strengths may require different parameters for adequate image quality, such as TR, TE and Bandwidth.

Section	Setting	Knee (High-Resolution)	Knee (Low-resolution, needed if T/R-coil is used for High-resolution)	Hip	Ankle
	Coil	T/R (for example: Speeder) and receive only Coil (for example: 16chFlex SPDR L)	Body	Body	Body
	Resolution	512x512	256x256	256x256	256x256
	Contrast	Fat Sat On	Fat Sat On	Fat Sat Off	Fat Sat Off
	Field of view (mm)	220	220	240	220
	Number of slices	~80 – 110	~20-40	~15 – 20	~15 – 20
	Slice spacing (mm)	0	0	2	2
	Acquisition plane	Sagittal	Sagittal	Axial	Axial
PAS	Pulse sequence	FE 3D	FE 3D	2D T1 TSE (FSE-XL)	2D T1 TSE (FSE-XL)
	TR	20	20	400 – 700	400 – 700
	TE	Select the shortest available (4-10)	Select the shortest available (4-10)	Select the shortest available (9-20)	Select the shortest available (9-20)
	Flip Angle	12	12	90	90
	Slice thickness (mm)	1	4-6	5	5
	Bandwidth	100	122	200	200

3.5   Hitachi Protocol

Parameters listed in table below are recommended for 1.5 Tesla systems. Different magnetic field strengths may require different parameters for adequate image quality, such as TR, TE and Bandwidth.

Parameters Header	Parameters	Knee	Hip	Ankle
-	Coil	**Receive only**	Body (inherited)	Body (inherited)
Sequence	Slice Plane	Sagittal	Axial	Axial
	2D/3D	3D	2D	2D
	Sequence	RSSG	primeFSE	primeFSE
	Echo Time Mode	N/A	ShortET	ShortET
	Shim Mode	Regional	Volume	Volume
	Oblique	Limited	Limited	Limited
Seq. Parameters	FOV	200	360	260
	TR	30	600	600
	TE	~8	10	10
	FA	30	90	90
	IR Pulse	Off	Off	Off
	Thickness	2	5	5
	Interval	N/A	7	7
	Slice # / Multislice	60	20	20
	Recon Pitch	1	N/A	N/A
	Recon Slice	120	N/A	N/A
	Slice Reject %	16	N/A	N/A
	Multi Slab	1	N/A	N/A
	Multi Echo	N/A	1	1
	Multi Acquisition	1	1	1
	Mode	Single Slice	Interleaved	Interleaved
	Stacks	1	1	1
	Freq #	256	256	256
	Phase #	256	256	256
	Recon Matrix	512	256	256
	NSA	1	2	1
	AFR %	0	0	0
	E. Factor	N/A	2	2
	Echo Alloc.	Sequential	Centric	Centric
	DE Pulse	N/A	Off	Off
Advanced	Presat	0	0	0
	Rephase	Off	Slice	Off

Parameters Header	Parameters	Knee	Hip	Ankle
	Bandwidth (kHz)	30	48	60
	Read FOV	Manual	Off	Off
	Size (%)	80	100	100
	Antialiasing	Off	Off	Off
	Phase Dir. A	R-L	A-P	A-P
	Phase Dir. S	A-P	A-P	A-P
	Phase Dir. C	R-L	H-F	H-F
Saturation	Saturation	Water Excitation	Off	Off
	Wave	1-2-1	N/A	N/A
	Freq Graph	On	Off	Off
Scan Control	Scan Mode	Every	Every	Every
	Multi Scan Mode	Normal	Normal	Normal
	Table Move	Off	Off	Off
Rapid	Rapid(Phase)	1	1	1
	Rapid (Slice)	1	N/A	N/A
Filter / Post processing	Org Image	On	On	On
	Image Type	Abs	Abs	Abs
	Raw Data Save	Off	Off	Off
	Truncation	On	On	On
	Shading	Off	Off	Off
	Adaptive Filter	Off	Off	Off
	Edge Enhance	Off	Off	Off
	MIP Image	Off	Off	Off
	W-Width 1	1000	1000	1000
	W Level 1	500	500	500
Positioning	Slice Ord. S /A	L-R	H-F	H-F
	Radial Stack	Off	Off	Off
	Line/Box	N/A	Line	Line
	Guide Line	Yes	Yes	Yes
	G. Intvl	On	On	On
Others	Receiver Coil	Auto	TR-Body	TR-Body
	Mode	Default	TR-Body	TR-Body
	TM Program	No	No	No
	Morning QA	Off	Off	Off
	Silent	Off	N/A	N/A

4 MRI sample and Image Transfer through www.zimmersms.com

Note: Reduced identification **is NOT required**

Refer to *HT-CTS-009- Adding & Qualifying Scan Equipment for a PSI Scan Center* that can be downloaded in the Help Section of ZSMS

Follow the steps below for the transfer of images through www.zimmersms.com:

1. **Acquire** the images according to the appropriate protocol in Section 3 of this document.

   Note: For MRI sample for Qualification, use a **sample MR image** set performed on a **Zimmer patient** (Zimmer related patient case)

2. **Save** the scan in the DICOM file format

3. **Compress** the DICOM all together using a Zip (compressed) file format.

   First, copy the folder containing all DICOM images on your desktop. Then, right click on this folder and select Compress:
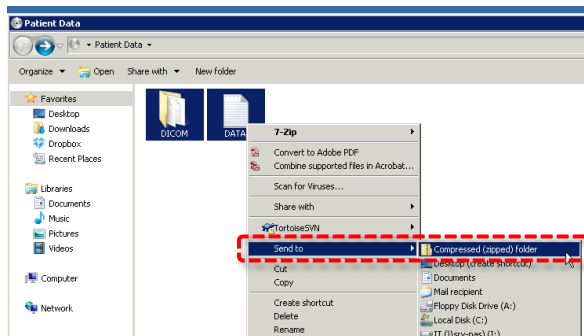
On a PC: **On a MAC:**
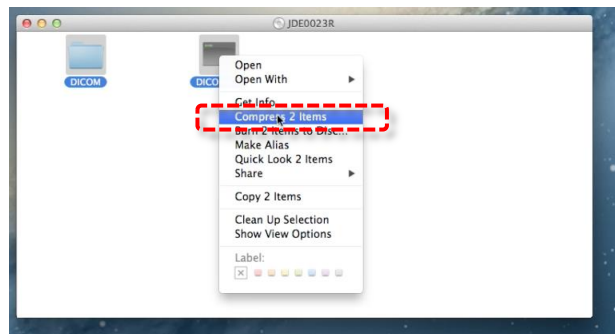
4. **Rename** the ZIP (compressed) file:
   a. **For a Test image:** rename as ABC123L11XY14US.zip.
   b. **For a patient case:** rename with the PSI case ID provided corresponding to the patient

5. **Upload** the images on ZSMS

For **Test images** (pre-requisite to qualify an imaging center):

• In "Cases" tab, click on "Manage Scanners" and then on the link under the "Files" column to bring you to the upload page.

For a **Patient Case**:

- Transfer the images by clicking on "UPLOAD SCANS" in the corresponding case which will bring you to the upload page.

5   MRI Sample and Image Transfer through other transfer methods

(CD, DVD, USB, FTP, other transfer methods such as www.wetransfer.com, www.hightail.com[1])

Notes: Reduced identification **is ALWAYS required**.

Do NOT use "ALTE" (DICOM export via PACS) to save the images. "AGFA" or preferably CD should be used.

If you are located in EMEA, refer to *806 001 - PSI Logistics Guide EMEA.*

The imaging center will be responsible to reduce the patient identification of the DICOM image set. The reduced identification shall remove any element permitting to identify the patient. This includes but is not be limited to:

- Patient Name
- Date Of Birth
- Social Insurance Number
- Phone Number(s)

Follow the steps below for the transfer of images:

1. **Acquire** the images according to the appropriate protocol in Section 3 of this document.

   Note: For MRI sample for Qualification, use a **sample MR image** set performed on a **Zimmer patient** (Zimmer related patient case)

2. **Save** the scan in the DICOM file format

3. **Reduced identification** the DICOM images as shown in Table 1 (reduced identification differs if the MRI sample is for qualification or patient case).

4. **Compress** the DICOM all together using a Zip (compressed) file format.

   First, copy the folder containing all DICOM images on your desktop. Then, right click on this folder and select Compress:

On a PC:
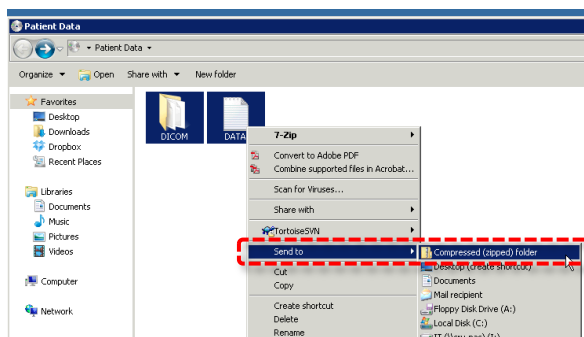
On a MAC:
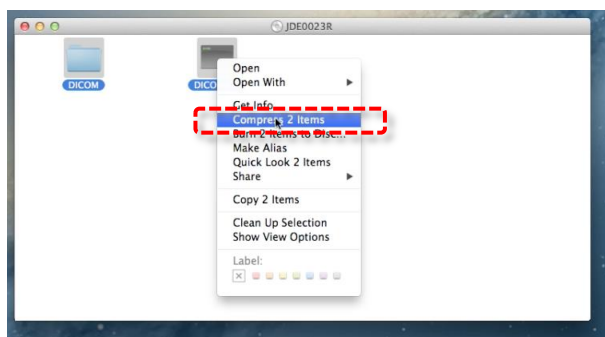
5. **Rename** the ZIP (compressed) file according to Table 1 first row:

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[1] Zimmer does not endorse or recommend any particular transfer method. It is the responsibility of the transferring party to ensure that the transfer method complies with applicable privacy and security laws and regulations.

Table 1 | Reduced identification Parameters

| DICOM Field	Test images (QUALIFICATION) Same values for all qualification cases	PATIENT Different values for every case; provided by the Zimmer Sales associate
	Value	**Value**
PatientName	**ABC1234L** (Put this actual value)	**XXX1111R** (Zimmer Case ID provided by Zimmer CAS) Can be 8 or 15 characters
PatientID (optional)	**HOSP12345** (Put this actual value)	**XXXX11111** (Hospital Patient ID)
PatientBirthDate	**1900/01/01** (If date can't be deleted, put this actual value)	**1900/01/01** (If date can't be deleted, put this actual value)

Example for a Qualification set of images:

0010	Group		
0010-0010	PatientName	PN	ABC1234L
0010-0020	PatientID	LO	HOSP12345

6. **Transfer** the zip file to Zimmer per chosen method (CD, DVD, USB, FTP, www.wetransfer.com)
   Note: when using www.wetransfer.com or www.hightail.com or any other web transfer service, send images to zimmerpsi@zimmercas.com
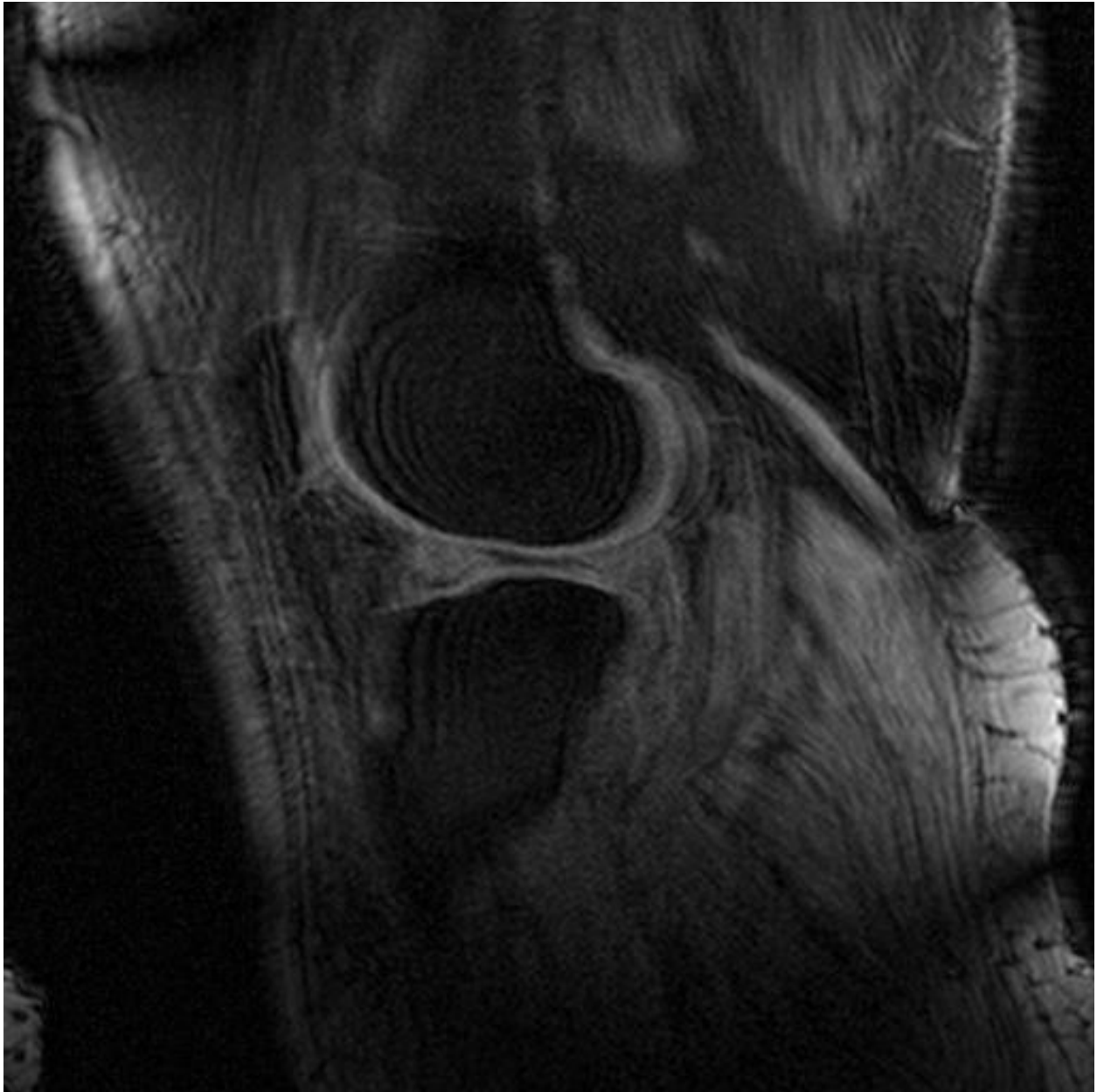
6 Sample Images & Common Problems

Example of Accepted Image
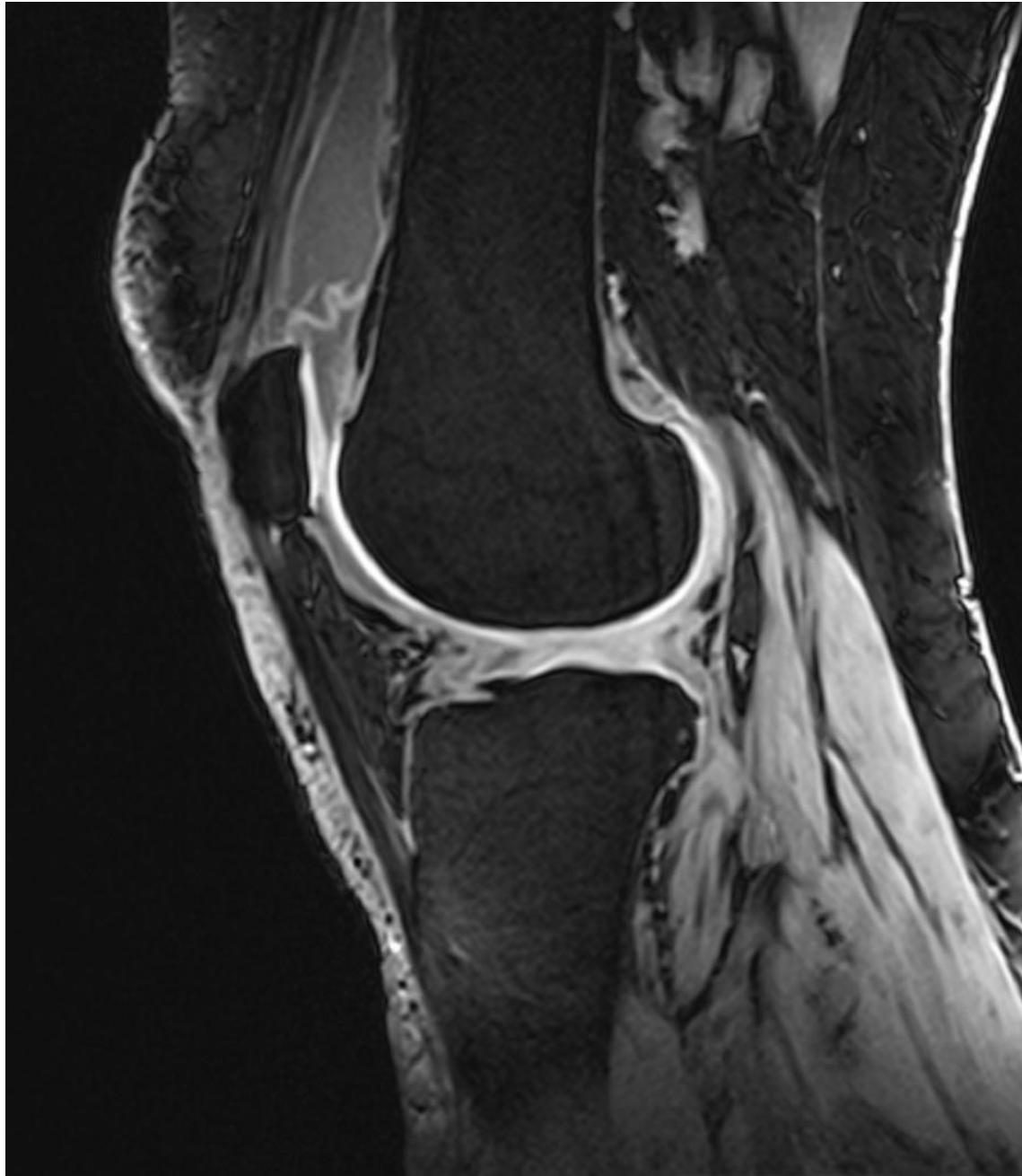
✅	Good image quality example: the cartilage at the patella-femoral and femoral-tibial junctions is clearly visible. The cartilage border is clear, it is not too blurry. Low noise and artifacts occurrence.

Example of Rejected Images

This image would be rejected because of the:

- Ringing artifacts: contour like pattern visible on the posterior condyle of this image.
- Grainy texture of the image.

Example of Rejected Images

This image would be rejected because of the:
- Grainy texture of the image
- Blurred: unable to distinguish the femoral and tibial cartilage

7 Zimmer Contact Information

Manufacturer

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Montreal (Quebec) H3C 2N6
CANADA
Tel: 1 (514) 395-8883
Fax: 1 (514) 878-3801

Web site: www.zimmer.com
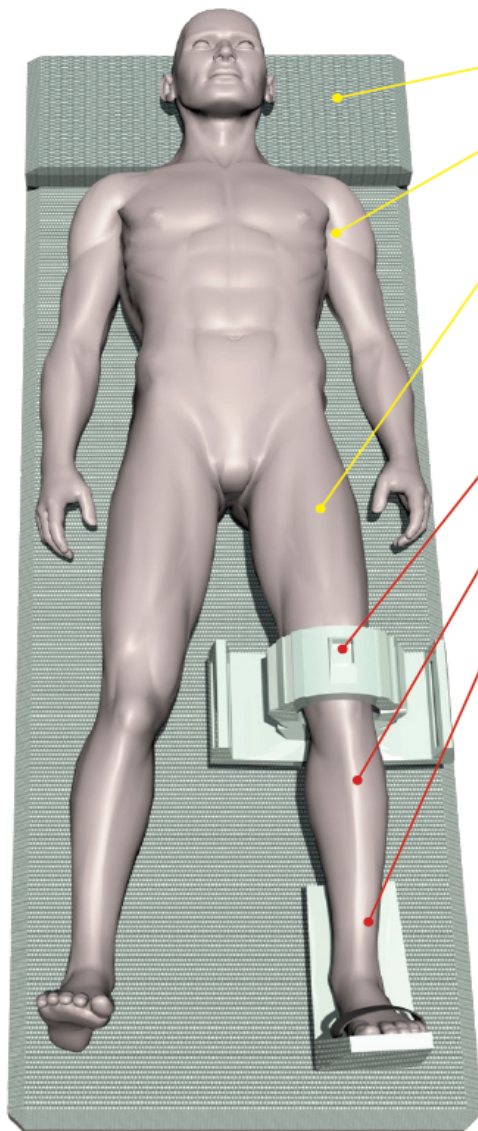**Email:** ZimmerPSI@zimmercas.com

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Customer Support

Phone: 1 (866) 336-7846

European Community (EC) Representative

Zimmer U.K. Ltd.
9 Lancaster Place
South Marston Park
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Your progress. Our promise."

Patient set-up diagram for best imaging outcomes

To increase patient comfort and immobilization, you can:

- Add 1 or 2 pillows if needed for patient comfort
- Use larger upper torso strap if needed for extended immobilization
- or Use medium thigh strap if needed for extended immobilization

For proper patient to table set-up, you should:

- Use foam for the support of the back of the knee (for patient comfort and to remove SI pressure from the pelvic area; unaffected leg may also be supported)
- Seams should be to the back of knee– secure with wrap strapping
- Small strap for tibia between flex wrap and ankle immobilizer
- Ankle immobilizer if available; if not, use sand bags M/L

Note: Slight flexion of the leg is normal but do not over flex.

Special note: If using a hard cage dedicated knee coil, place the ankle/foot into ankle immobilizer. Strapping of the tibia is highly encouraged but not a critical need.

Helpful Things to Remember

- This set up guide is for patient to table reference ONLY.
- NEVER use T/R surface coils within main body coil.
- ALWAYS use the approved surface coil that was selected at time of qualification.
- NEVER process a scan if metal artifacts are present in the Knee.
- Do not reposition patient once zero has been established at the start point, except upon T/R-coil removal.

- For PHILIPS scanners
  1. The order is Knee, Ankle and Hip
  2. Apply scout coordinate to all planes (x-y-z or a-b-c) to ensure planes are focused and targeting the same FOV.

- For models with table coordinate display on front of scanner, follow the next steps to perform pre-scouts:
  1. Zero at patient Ankle; Center; Press zero
  2. Manually shift table "IN" to patient Knee; Center; Write down coordinate table position
  3. Manually shift table "IN" to patient Hip; Center; Write down coordinate table position
  4. Manually shift table "OUT" completely until it stops
  5. Repeat step 1
  6. Send patient "in"

- If you see motion artifact, re-scan that sequence before continuing. A motion artifact scan would be rejected.