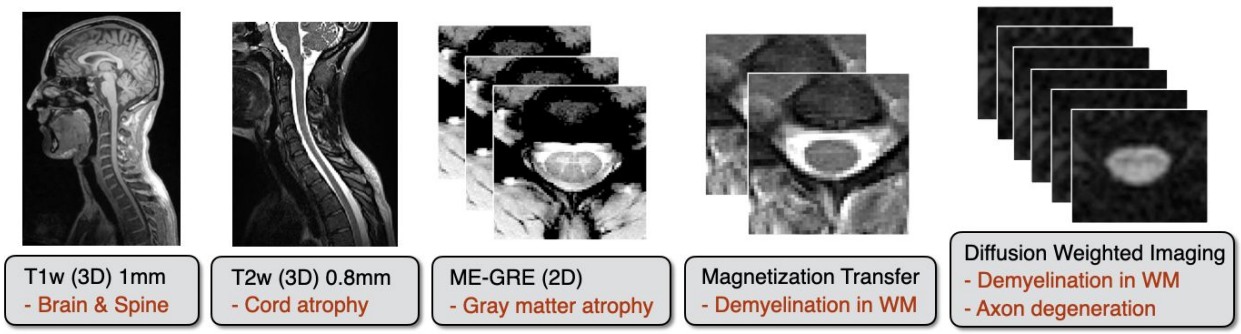
Spine Generic Protocol: Acquisition Guidelines



This Standard Operating Procedure (SOP) accompanies the spinal cord MRI acquisition protocol available at: https://github.com/spine-generic/protocols.

Subject preparation

Coil

		Cervical	Thoracic/Lumbar
GE	**HD/HDxt**	8-ch Cervical Thoracic Lumbar (CTL) array	8-ch CTL array
	PETMR	19-ch Head Neck Unit (HNU) array	14-ch Central Molecular imaging Array (CMA)
	MR750w	16-ch Head Neck Spine (HNS) array	48-ch Geometry Embracing Method Phased Array (GEMPA)
Philips	**Achieva**	16-ch head/neck/neurovascular or 32-ch head coil	15-ch posterior spine**
	Ingenia*		12-ch posterior array**
Siemens	**Trio**	12-ch brain + 4-ch neck array + spine array**	Spine array**
	Verio		
	Skyra	64-ch head/neck*** or 20-ch head/neck + spine array**	
	Prisma		

Table 1. *Recommended receive coils for SC imaging for GE, Philips and Siemens systems. *: (i) posterior spine coil could also be used depending on coverage, (ii) for thoracic/lumbar SC imaging; anterior coil could be used to improve image quality in sequences with anterior-posterior phase-encoding. **: The relevant elements of the spine array are to be selected depending on the region to cover. When using "auto select" (Siemens) or "SmartSelect" (Philips), elements will be automatically selected based on the slice positioning. It is advised to use it. ***: preferred.*

Subject Setup

Cushions and padding: Used to limit head tilting and lordosis so that the spine can be as straight as possible in the imaging region (see **Figure 1**). This will permit acquisition of thick slices (~5mm), orthogonal to the cord with minimum partial volume effect.

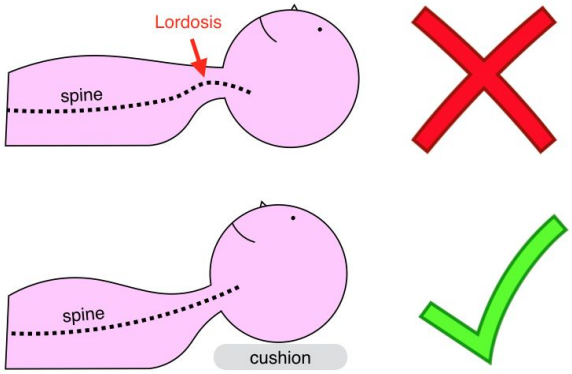


Figure 1. *Suggested subject positioning: Use a cushion to minimize cervical lordosis (bottom panel)*

Inform subject
Ask the subject not to move during scans and show them how to swallow without moving their head.

Pulse oximeter
Do not forget to install the pulse oximeter for cardiac gating on the DWI scan.

Laser marker
If you are doing brain & cervical cord imaging, mark the isocenter right below the nose (see **Figure 2**).

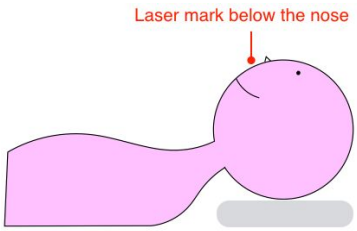


Figure 2. *Recommended location for isocenter position.*

T1w

Adjust the FOV so that it includes the whole head, as shown in **Figure 3**.

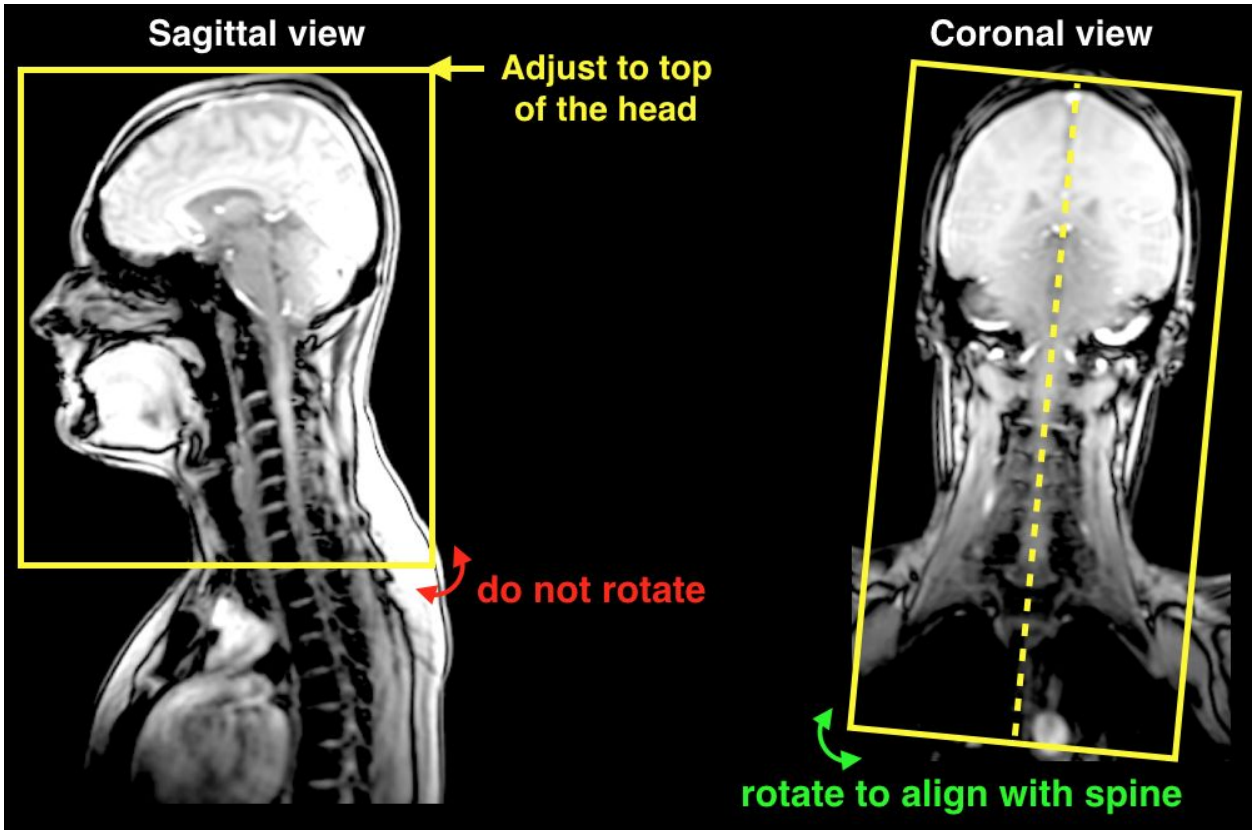


Figure 3. *Positioning of FOV for T1w scans.*

⚠ **GE users:** To avoid confusion with regards to the slice orientation, the protocol is saved as "sagittal". Please click on "oblique" to be able to rotate the slice in the coronal plane.

Optional: To have the images reconstructed at the proper matrix size, click on "Save Rx → "Scan", then click on "Research" → "Download". Then Click on "Research" → "Display CVs". Then, modify the following CVs accordingly[1]:

- `rhimsize=320`
- `rhrcxres=320`
- `rhrcyres=256`

[1] You can check on the console if the field was modified appropriately, by looking at the "image header", after reconstruction. You should get: (0x0028, 0x0010)=192; (0x0028, 0x0030)=1\1

T2w

Center the FOV at C3-C4 as shown in **Figure 4**. Align along the spine (see coronal view).

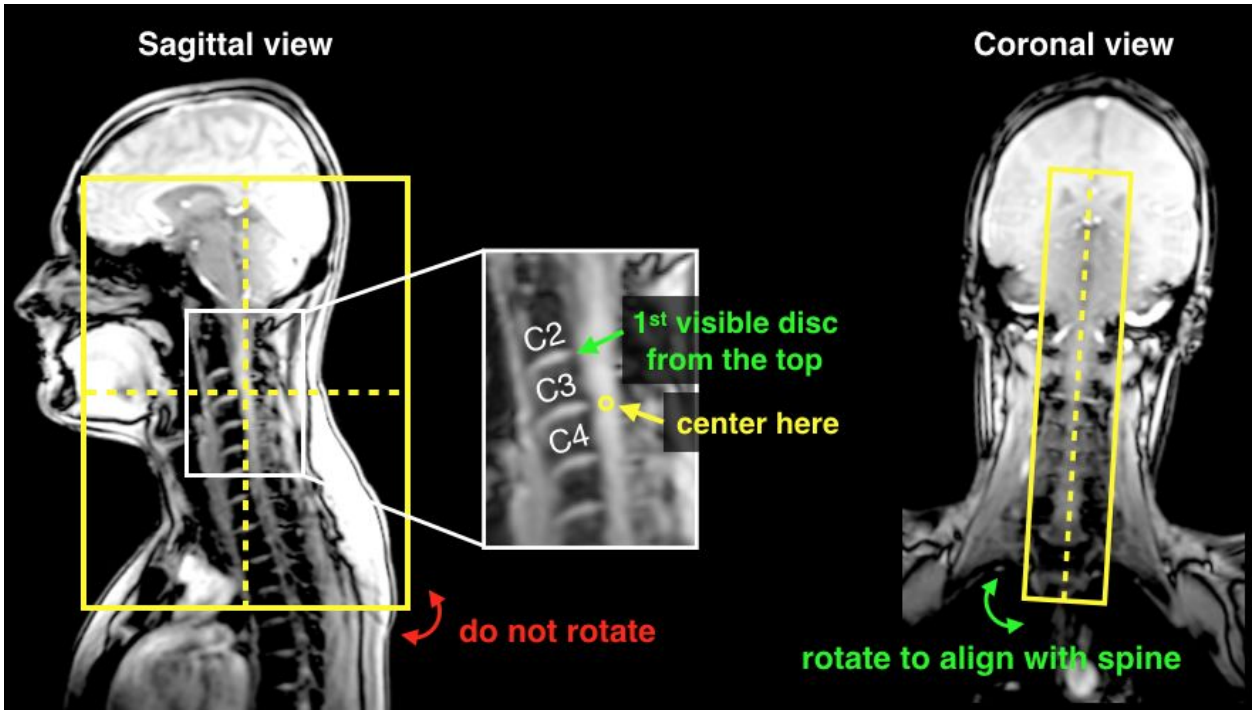


Figure 4. *Positioning of FOV for T2w scans.*

⚠ **GE users:** To avoid confusion with regards to the slice orientation, the protocol is saved as “sagittal”. Please click on “oblique” to be able to rotate the slice in the coronal plane.

Optional: To have the images reconstructed at the proper matrix size, click on “Save Rx → “Scan”, then click on “Research” → “Download”. Then Click on “Research” → “Display CVs”. Then, modify the following CVs accordingly:

- `rhimsize=320`
- `rhrcxres=256`
- `rhrcyres=256`

GRE-ME

The FOV center and orientation should be the same as for the DWI scan. Normally, if you imported the full protocol, the FOV should be copied automatically from the DWI scan. If not, please do "copy parameters" (center of FOV and orientation). **Shimming**: Adjust shim box so that it follows the spine as closely as possible (see **Figure 8**).

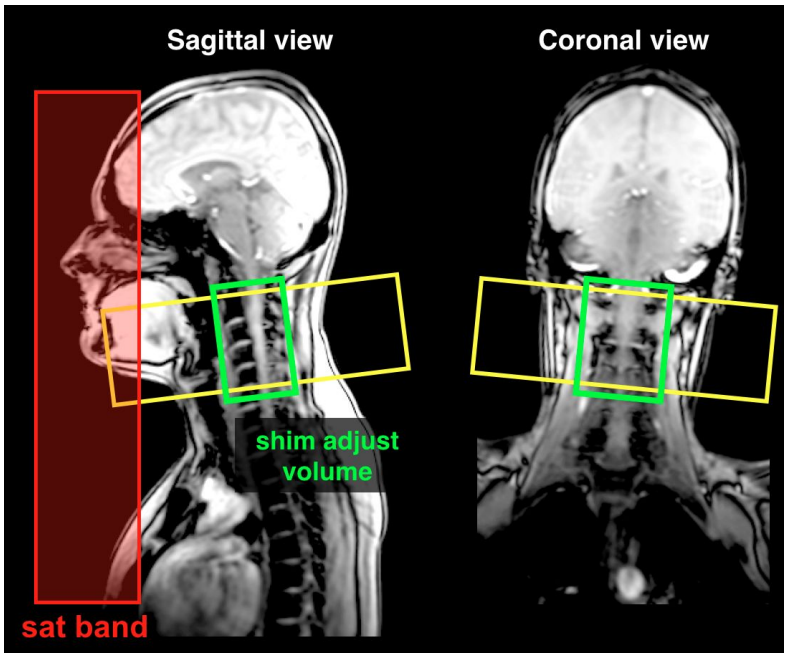


Figure 8. *Positioning of the FOV, shim box and saturation bands for the GRE-ME scan. Siemens and GE users: the saturation band is already automatically positioned. Philips users: the saturation bands are "invisible" on this sequence, but are nevertheless applied.*

⚠ **GE users:** To avoid confusion with regards to the slice orientation, the protocol is saved as "axial". Please click on "oblique" to be able to rotate the slice in the sagittal and coronal planes.

Optional: To have the images reconstructed at the proper matrix size, click on "Save Rx → "Scan", then click on "Research" → "Download". Then Click on "Research" → "Display CVs". Then, modify the following CVs accordingly[2]:

- `rhimsize=448`
- `rhrcxres=224`
- `rhrcyres=224`

[2] You can check on the console if the field was modified appropriately, by looking at the "image header", after reconstruction. You should get: (0x0028, 0x0030)=0.5\0.5

GRE-MT1 / MT0 / T1w

The FOV center and orientation should be the same as for the DWI scan. Normally, if you imported the full protocol, the FOV should be copied automatically from the DWI scan. If not, please do “copy parameters” (center of FOV and orientation).

Shimming: Use “auto” mode.

SAR: If you get a SAR limitation on the MT scan, then increase the TR to the minimum suggested (e.g., going from 35ms to 36ms). In that case, it is very important that you also change the TR on the GRE-MT0 sequence (TR should be the same on the MT1 and MT0 scans).

⚠ **GE users:** To avoid confusion with regards to the slice orientation, the protocol is saved as “axial”. Please click on “oblique” to be able to rotate the slice in the sagittal and coronal planes.

To match the RF frequency of other vendors, modify the CV **`off_rfmt`**

Optional: To have the images reconstructed at the proper matrix size, click on “Save Rx → “Scan”, then click on “Research” → “Download”. Then Click on “Research” → “Display CVs”. Then, modify the following CVs accordingly:

- `rhimsize=192`
- `rhrcxres=172`
- `rhrcyres=172`

DWI

1) Center the FOV in the cord at the level of C3/C4 disc
2) Rotate the FOV such that slices are orthogonal to the spinal cord, in both the sagittal and coronal planes.

> ⚠ **GE users:** Change the “axial” to “oblique” to be able to rotate the FOV. When tilting the slice, the TE might increase by a few ms. If you wish to use the same TE throughout an entire study, we suggest you try tilting the FOV in the coronal and sagittal plane, and report what the minimum TE is. The more you tilt, the bigger the TE will be (hence lower SNR) but the more conservative you will be in keeping a fixed TE throughout the entire study.

3) Adjust the shim volume as shown in **Figure 5** (green box). Phase-encode should be A-P.

> ⚠ **GE users:** Click on “shim volume” and then center on the spinal cord. If you cannot modify the size of the shim box, don’t worry.

4) Refer to the appropriate figure below depending on your sequence/license:
(4a) (prefered) If you have ZoomIt (Siemens), ZOOM (Philips) or FOCUS (GE).
(4b) If you don’t have the license, use saturation bands for aliasing suppression.

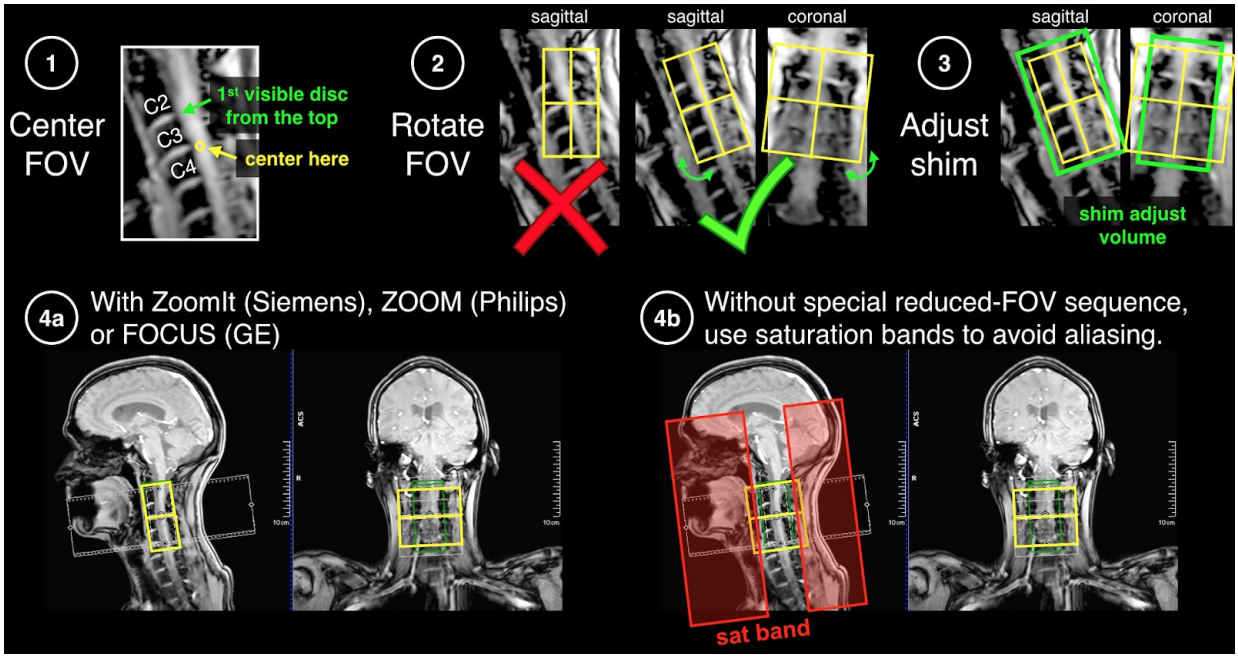


Figure 5. *Positioning of FOV, shim box and saturation bands for the DWI scan.*

Before starting the acquisition, make sure the PulseOx trigger is working. It should look like what is shown in **Figure 6**:

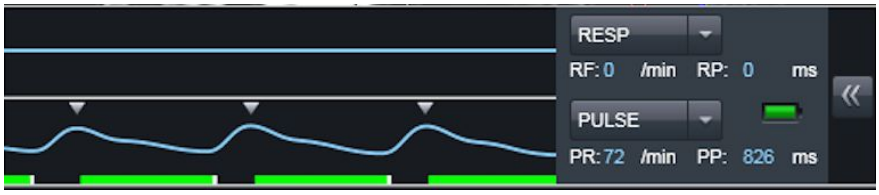


Figure 6. *Example of pulse oximeter trace on a Siemens scanner for triggered acquisition (small triangles).*

During acquisition, look at the images to make sure everything is OK. Images should look like those in **Figure 7**.

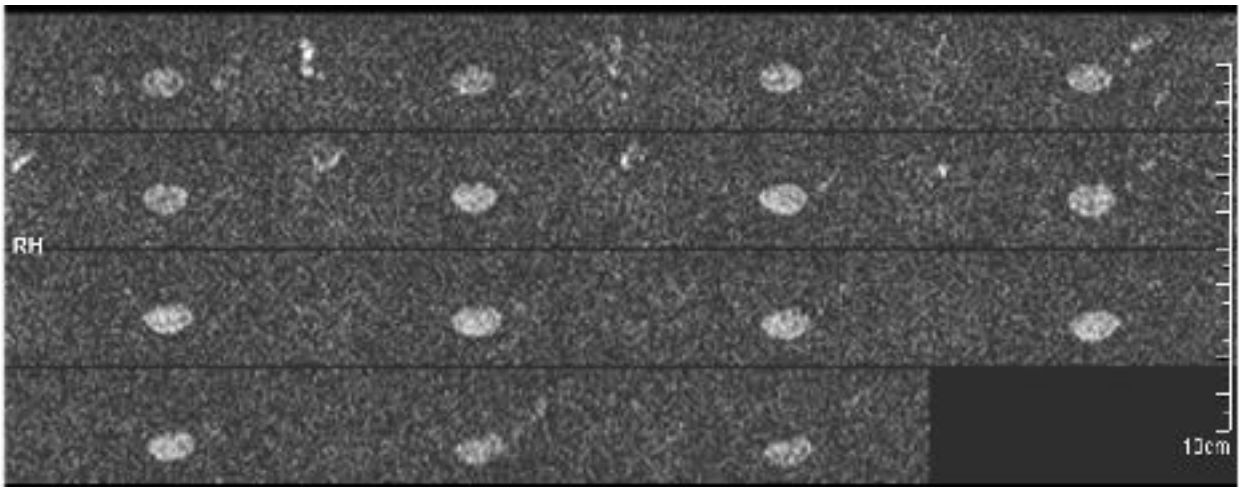


Figure 7. *Example of what a diffusion-weighted image should look like on a Siemens system. In this example, all 15 slices are represented as a 4x4 mosaic.*

⚠ **GE users:** The current protocol (v2) is saved without pulseOx gating. We recommend you add it (select “PG gating”).

Optional: To have the images reconstructed at the proper matrix size, click on “Save Rx → “Scan”, then click on “Research” → “Download”. Then Click on “Research” → “Display CVs”. Then, modify the following CVs accordingly:

- `rhimsize=96`
- `rhrcxres=86`
- `rhrcyres=43`