The SpondyloArthritis Research Consortium of Canada (SPARCC) Magnetic Resonance Imaging of the Sacroiliac Joints Acquisition Protocol

POSITIONING – patient and coils

- Patient lies supine, as straight as possible.
- Use anterior and posterior coils (antennae) – in large patients or if there is a steep lumbosacral angle, the anterior coil is especially important.
- Record relationship of anatomical structures to coil elements for follow-up reference.

SCOUTS

- Scout images in 3 planes. It may be helpful to include hip joints.
- True sagittal scout – a true sagittal scout should be performed in addition to the 3 plane scout.

LOCATION and ANGLES

Semi-coronal or tilted coronal orientation

A coronal sequence is performed with the stack rotated so that the stack is parallel to the longitudinal axis of the sacrum at S2 (not S1):

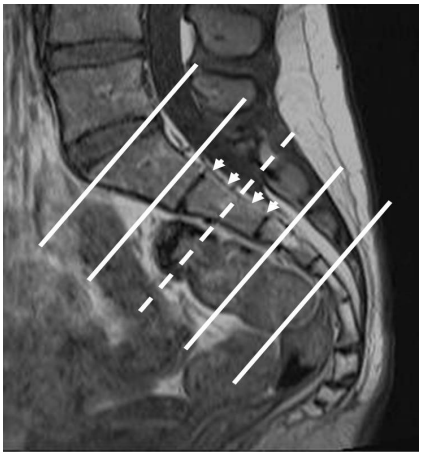
- Centering point of the stack –
  - Left/right - midline
  - Head/Foot - At the sclerotic scar formed by the vestigial disc between the S1 and S2 vertebral bodies (the cranial end of S2)
  - Anterior/Posterior - place the centre of the stack at the anterior border of the S1/S2 vestigial disc (or at least no further posterior than the centre of the S1/S2 vestigial disc)
- Angling the stack –
  - Perpendicular to above “true sagittal scout”, and
  - Rotate until parallel to the posterior surface of the S2 vertebral body (anterior border of spinal canal at S2). Do NOT use L5/S1 disc or S1 vertebra to orientate the stack.

The semicoronal sequence should be planned so that the centre (dashed line) of a stack of 19 images 3 mm thick is positioned at the anterior border of the sclerotic line representing the junction of the 1st and 2nd sacral segments (arrowhead). Orientation of the semicoronal sequence is parallel to the dorsal cortex of the S2 vertebra (anterior border of sacral spinal canal at S2).

The semicoronal sequence must include one slice anterior to the SI joint and all of the cartilage compartment but complete coverage of the entire ligament compartment is not required.

Semi-axial or tilted axial orientation
An axial sequence is performed with the stack rotated so that it is perpendicular (90°) to the semi-coronal sequence:

- Centering point of stack –
  - Left/right - midline
  - Head/Foot - At the centre of S2 vertebral body
  - Anterior/Posterior – mid pelvis.
- Angling the stack –
  - Perpendicular to the "semi-coronal" sequence.



The semiaxial sequence should be planned so that the centre (dashed line) of a stack of images is positioned at the centre of the S2 vertebra, or as low as S3. Orientation of the semiaxial sequence is perpendicular to the dorsal cortex of the S2 vertebra (anterior border of sacral spinal canal at S2) (arrowheads).

The semiaxial sequence must include all of the first four sacral vertebrae and the pubic symphysis. Including the hips joints may be considered depending on whether or not other additional sequences are performed.

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SEQUENCES
A complete diagnostic MRI examination of the sacroiliac joints (SIJ) is required. Two sequences are required for scoring and classification purposes. Additional sequences are required for a complete diagnostic MRI of the SIJ and this would usually include one sequence for further evaluation of joint erosion and at least one sequence in the axial plane.

Sequences required for scoring and classification
1) Semi-Coronal T1
2) Semi-Coronal STIR/T2FS

Sequences required to complete a diagnostic MRI of the SIJ
3) A sequence to evaluate subchondral erosion.
   Examples include: Semi-Coronal T1FS spin echo, or T1 Dixon or 3D gradient echo FS. Local site may choose own sequence.
4) A sequence to evaluate the SIJ in the axial plane.
   Examples include: Semi-Axial STIR/T2FS. Local site may choose own sequence.

Contrast enhancement is not required.
Additional sequences may be performed as per local site preference.

SEQUENCE PARAMETERS

Sequences required for scoring and classification

1) **SEMI-CORONAL T1**

At both 1.5T and 3T, spatial resolution of the Cor T1 should be maximized to optimize identification of small lesions.

- Field of view – **Required - 200-220mm**
  - Maximum 240mm FoV is permitted if absolutely necessary at 1.5T.
- Slice thickness – **Required 3mm**
- Slice gap – **maximum 10%**
- Repetition Time (TR) – range 400-600 msec for 1.5T, range 500-800 msec for 3T
- Echo Time (TE) – **10-13 msec** at both 1.5T and 3T.
  - TE must be as short as possible and must be the first echo of the echo train.
- Echo train length (turbo factor) – **maximum 3**.
- Phase encoding direction – left-right is recommended with oversampling as necessary to prevent fold-over/wrap/aliasing artefacts.
- Acquisition matrix size – spatial resolution. This is intimately related to FoV and overall signal strength.
  - 3T MRI – spatial resolution must be minimum 384, but should be higher and preferably a 512 acquisition in the frequency direction, and with phase matrix of 50-80%. For example:
    - 220mm FoV - 3mm thick – 512 freq x 320 phase (62.5%) (0.30mm^2 pixel size and 0.89 mm^3 voxel size), or
    - 200mm FoV - 3mm thick – 448 freq x 256 phase (57%) (0.35mm^2 pixel size and 1.05 mm^3 voxel size)
  - 1.5 T MRI - FoV 220mm is preferred:
    - 220mm FoV - 3mm thick – 384 freq x 224 phase (58%) (0.56mm^2 pixel size and 1.69 mm^3 voxel size).
    - Higher spatial resolution than this is desirable and is to be encouraged but may be difficult to achieve with older 1.5T MRI scanners.

Notes:

- It is not necessary to include the entire ligamentous compartment of the joint or the iliac crests as these anatomical areas do not provide significant information re structural damage changes.
- Descriptions of matrix size apply to the acquisition matrix. The reconstruction matrix may be even higher than the acquisition matrix, according to local site preference.

2) **SEMI-CORONAL STIR**

Fat suppression should be optimized with good T2 weighting for inflammation detection in erythropoietic bone marrow.

- Inversion Time –
  - 1.5T MRI – **required range 155-165 msec** – recommend 160 msec
  - 3T MRI – **required range 200-220 msec** – recommend 200 msec

- Repetition Time (TR) – **Minimum 3000 msec** at both 1.5T and 3T
- Echo Time (TE) – **Minimum 55 msec** at both 1.5T and 3T
- Echo train length (turbo factor) – No specific restriction but a typical range is 7-15. More than this, longer ETL tends to result in gradual signal degradation and excessive T2 weighting.
- Field of View – 220-280 mm
- The FoV does not have to match the COR T1 spin echo but it MUST match location, orientation, slice thickness and slice gap, so that the STIR and T1 images are co-located.
- Acquisition matrix size – spatial resolution. This is intimately related to FoV and overall signal strength. There is no specific requirement but if acquired at larger FoV (e.g. 280mm) then a higher spatial resolution matrix is expected, for example 448x256.

Notes:

- A larger FoV is not required but is permitted and if used, it does allow visualization of enthesopathy in the iliac crests and more signal allows faster scanning.
- Detecting inflammation in erythropoietic bone marrow requires more T2 weighting than detecting inflammation in fatty bone marrow in the extremities.
- Fat suppression is suboptimal if too short an Inversion Time is selected.
- The ligamentous compartment of the SI joint does not necessarily have to be included as this anatomical area will be included in the axial sequence.

Sequences required to complete a diagnostic MRI of the SIJ – suggested parameters

3) SEMI-CORONAL Erosion Specific Sequence

Good resolution is required

An 'erosion-specific' sequence is required in the semi-coronal plane. This may be T1 spin echo with fat saturation (T1FS), T1 Dixon, or a high resolution T1-weighted 3D gradient echo sequence with fat saturation such as Siemens VIBE, Philips THRIVE, General Electric FAME/LAVA, Toshiba 3D QUICK. Some centres may prefer to perform high-resolution susceptibility-weighted imaging (SWI) but there are advantages and disadvantages to using SWI and VIBE FS (or equivalent) appears to most closely resemble CT scanning. The parameters should be similar to COR T1 except:

- T1FS - Slight increase in Field of View, or decrease in resolution to compensate for the loss of signal associated with the fat saturation.
- T1 Dixon – should be almost identical to the T1.
- T1FS VIBE (or equivalent) – Should be the same FoV as T1, and 1-2 mm thick with maximal possible resolution.

Note:

- The entire purpose of this sequence is to enhance bone-soft tissue contrast and maximize spatial resolution to allow optimal visualization of small erosions. If a high resolution 3D gradient echo sequence is performed, then parameters should be optimized to achieve maximal resolution in the semi-coronal plane. Multiplanar 2D reconstructions are not a substitute for poor resolution in the plane of acquisition.

4) SEMI-AXIAL Sequence

STIR or T2FS is suggested but T1 or Dixon imaging may be performed

For diagnostic purposes, an axial sequence is required. This can be done in the transverse plane without angles but a semi-axial orientation is preferred, perpendicular to the semi-coronal sequences as above. This minimizes partial volume averaging in the SI joint and allows image capture of the symphysis pubis without compromising image quality or adding extra slices. Parameters should be similar to COR STIR / T2FS except:

- Slice thickness may be 4mm.
- Enough slices must be included to capture the symphysis pubis

Notes:

- There is no need to have the SI joints in the center of the axial images as this may prevent visualization of the pubic symphysis.
- Consider including the hips joints, depending on whether the local site prefers to include additional sequences of the entire pelvis.

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