A Practical Guide to Interpret MRI Features of New Bone Formation in Axial Spondyloarthritis

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Spondyloarthritis (SpA)

→ **Group of inflammatory rheumatic diseases**
  (psoriatic arthritis, arthritis associated with ulcerative colitis or Crohn’s disease, reactive arthritis, juvenile SpA, undifferentiated SpA and ankylosing spondylitis)

→ **Inter-related** by clinical, genetic, radiological, and therapeutic characteristics

→ Divided in **axial and peripheral SpA**, based on predominant clinical phenotype
**BACKGROUND**

**Axial SpA**

- **Predominant axial involvement** (inflammatory back pain), with or without peripheral manifestations

- Manifests as **arthritis and enthesitis of the axial skeleton**, clinically associated with inflammatory back pain

**Hallmark features**

- **Active inflammation** and post-inflammation structural lesions (erosions, sclerosis and fatty degeneration of bone marrow)

- **New bone formation**
MRI FEATURES OF NEW BONE FORMATION IN THE SACROILIAC JOINTS
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BACKGROUND

1. Inflammation → **erosions** (a.o. structural damage)

2. Erosive cavity → **tissue with high SI T1W**, i.e. ‘backfill’ or ‘fat metaplasia in an erosion cavity’

3. Final stage: **ankylosis** of the joint

Current hypothesis: ‘backfill’ is an **intermediate step between erosion and ankylosis** – validation is necessary

(SI T1W = signal intensity on T1-weighted MR images)
INTRA-ARTICULAR HIGH SIGNAL INTENSITY IN THE SACROILIAC JOINT SPACE ON T1W MR

MRI DEFINITION

• Location:
  • Intra-articular

• Signal intensity:
  • High on T1W MR—similar to adipose tissue

• Amount:
  • ≥ 2 consecutive slices
  • ≥ 10 mm parallel to the subchondral bone plate on ≥ 1 slice

DIAGNOSTIC VALUE

• High specificity and LR+
• Positive MRI for (structural) sacroiliitis, even without concomitant bone marrow edema (BME)

Erosive damage → ‘Backfill’
INTRA-ARTICULAR HIGH SIGNAL INTENSITY IN THE SACROILIAC JOINT SPACE ON T1W MR

IMAGING CASE

patient with SpA

- Coronal oblique T1W MR images:
  - *Intra-articular high signal intensity* (arrows) filling up the eroded bone (i.e. 'backfill')
  - Extensive fatty degeneration of the bone marrow on the sacral side of the joints, i.e. post-inflammatory structural changes
ANKYLOSIS OF THE SACROILIAC JOINTS

MRI DEFINITION

- **Bony bridging**
- Obliteration of articular cortical margins
- Signal intensity:
  - Low on all MR sequences
  - High on T1W – in case of fatty bone marrow

DIAGNOSTIC VALUE

- **High specificity and LR+**
- **End-stage structural SpA**

’Backfill’ → Ankylosis
ANKYLOSIS OF THE SACROILIAC JOINTS

IMAGING CASE
patient with SpA

- Coronal oblique T1W (a) and STIR (b) MRI:
  - **Bony fusion of the sacroiliac joints**
  - Peri-articular high signal intensity on T1W, i.e. **fatty degeneration**
  - Low signal intensity on STIR
  - **Sclerotic remnants** of the joint (arrows)

- Radiography (c) confirms bony ankylosis
MRI FEATURES OF NEW BONE FORMATION AT THE DISCO-VERTEBRAL UNIT
**MRI FEATURES OF NEW BONE FORMATION AT THE DISCO-VERTEBRAL UNIT**

**BACKGROUND**
- 4 signal changes associated with new bone formation in the spine in axial SpA:
  - Non-bridging syndesmophytes
  - Vertebral corner bridging
  - Discal high signal intensity on T1W MR
  - Transdiscal ankylosis

**NOTE**
- Ankylosing spondylitis (prototype axial SpA):
  - Ossification of annulus fibrosus of the intervertebral disc
- Psoriatic arthritis
  - Ossification of adjacent connective tissues
  - Bony outgrowths develop from irregular to well-defined and eventually bridge

\( \text{SI T1W = signal intensity on T1-weighted MR images} \)
**Discal High Signal Intensity on T1W MR**

*Discal calcification*

**MRI Definition:**

- **High signal intensity** similar to adipose tissue on **T1W MR** images within the intervertebral disc

**Amount:**

- 2 consecutive slices
- ½ disc height on ≥ 1 slice
- ¼ vertebra width ≥ 1 slice

**Diagnostic Value:**

- One case-control study: discal high T1 signal intensity = **remarkably specific for SpA**
- Further research and validation required
Discal HIGH SIGNAL INTENSITY ON T1W MR

IMAGING CASE

patient with SpA, 45-year-old man

• Sagittal T1W MRI (a) and CT (b):
  • High signal intensity on T1W MR (long arrows) within the intervertebral disc
  • Discal calcification on CT (long arrows)
  • Discordance in visibility of syndesmophytes between CT and MRI (short arrows)
NON-BRIDGING SYNDENSMOPHYTES

‘Ossification at the Sharpey fibers of the annulus fibrosus of the intervertebral disc’

MRI DEFINITION

• Location:
  - Longitudinal bony outgrowths at the corners of the vertebral bodies, oriented craniocaudally

• Signal intensity:
  - Low on all MR sequences
  - High on T1W MR – in case of fatty bone marrow

DIAGNOSTIC VALUE

• Questionable diagnostic value on MRI:
  - Visibility: radiography > MRI
  - Frequently observed in patients without SpA
  - Not specific in absence of other signs of new bone formation

• Value for evaluation of disease progression is unknown
IMAGING CASE

patient without SpA

• Sagittal T1W MRI:
  • Anterior syndesmophyte formation at Th3-Th4 and Th4-Th5 (arrows)
  • No syndesmophyte bridging.
  • No other types of new bone formation or structural lesions.
VERTEBRAL CORNER BRIDGING

‘bridging syndesmophytes’

MRI DEFINITION

- **Bony fusion at the anterior or posterior corners** of the vertebrae
  - Expected location of annulus fibrosus

- Signal intensity:
  - Low on all MR sequences
  - High on T1W MR – in case of fatty bone marrow

DIAGNOSTIC VALUE

- Specific for axial SpA
- Indicator of SpA (<-> non-bridging syndesmophytes)
IMAGING CASE

patient with SpA, 57-year-old man

• T1W MRI (a) and radiography (b):
  • Bridging syndesmophytes (arrows)
  • ‘Bamboo spine’ configuration
  • Visibility of the anterior syndesmophytes:
    radiography > MRI
**TRANSDISCAL ANKYLOSIS**

‘Non-corner ankylosis’

**MRI DEFINITION**

- **Bony fusion crossing the center** of the intervertebral space
  - Expected location of the nucleus pulposus
- Obliteration of the cortical margins of the endplate
- Signal intensity:
  - Low on all MR sequences
  - High on T1W MR – in case of fatty bone marrow

**DIAGNOSTIC VALUE**

- **Specific for axial SpA**
- Considered a reliable indicator of SpA
IMAGING CASE

patient with SpA, 53-year-old woman

• Sagittal T1W MRI:
  • Bony fusion crossing the intervertebral space with obliteration of the endplates (*long arrows*)
  • High signal intensity of the intervertebral disc on T1W MRI (*short arrow*)
ANKYLOSIS OF THE INTERVERTEBRAL SYNOVIAL JOINTS

INTERVERTEBRAL SYNOVIAL JOINTS
• Costovertebral joints
• Costotransverse joints
• **Zygapophyseal (facet) joints**
  • Assessable on standard sagittal MRI

DIAGNOSTIC VALUE
• Facet joints can be primarily and early involved in the course of the disease

IMAGING CASE
*patient with SpA, 34-year-old man*

• Sagittal T1W MRI (a) and radiography (b):
  • Ankylosis of the facet joints of C2-C3, C6-C7, and C7-Th1 (arrows)
MRI FEATURES OF NEW BONE FORMATION IN THE STERNUM
MRI FEATURES OF NEW BONE FORMATION IN THE STERNUM

‘Ankylosis of the manubriosternal joint

or the sternoclavicular joints’

BACKGROUND

• Manubriosternal joint
  • Detailed evaluation possible on standard sagittal MRI
  • No saturation bands over the sternum
  • Coronal plane is also useful, axial plane is not

DIAGNOSTIC VALUE

• Further research is required
MRI FEATURES OF NEW BONE FORMATION IN THE STERNUM

IMAGING CASE

Extensive disease in a patient with SpA

• Sagittal T1W MRI:
  • Bony fusion of the manubriosternal joint (rectangle)
  • Syndesmophytes (dotted arrow)
  • Discal high signal intensity and/or progressive trandiscal ankylosis (short arrow)
  • Degenerative osteophytes (long arrow)
    • Increased mechanical loads on the remaining functional levels
PITFALLS IN MRI-IMAGING DIAGNOSIS
DIFFUSE IDIOPATHIC SKELETAL HYPEROSTOSIS (DISH): SPINE

BACKGROUND

• Bulky osteophytes on the right side of the thoracic spine
• Ossification of the anterior longitudinal ligament
• Resnick criteria:
  • ≥4 adjacent vertebrae
  • Preserved intervertebral disc space
  • No inflammatory/degenerative changes in the apophyseal and sacroiliac joints
• Growth angle:
  • Syndesmophytes: ≤45° from vertical
  • Spondylophytes: > 45° from vertical

IMAGING CASE

• Sagittal T1W MR image (a) and CT (b):
  • Bulky osteophytes (arrows) with, in this case, an average growth angle of > 45° from vertical
DIFFUSE IDIOPATHIC SKELETAL HYPEROSTOSIS (DISH): SACROIILIAC JOINTS

BACKGROUND

• Sacroiliac fusion, anterior and posterior bridging, and enthesseal bridging also occur significantly in DISH

IMAGING CASE

patient without SpA

• Axial T1W (a) and STIR (b) MRI:
  • Sclerotic ossification (arrows) at the anterosuperior sacroiliac joint
  • Focal BME on STIR (arrow)

→ BME in a patient with sacroiliac DISH can mimick active and structural sacroilitis
CONGENITAL VERTEBRAL FUSION

BACKGROUND
• Failure of segmentation during the fetal period:
  • Involvement of anterior and/or posterior elements (partial or complete).
  • ‘Waist’ at the level of the intervertebral disc
  • Height: sum of 2 vertebrae and intervertebral disc (not always in complete fusion)
  • Anteroposterior (AP) diameter: < in complete fusion

IMAGING CASE
• Sagittal T1W MRI:
  • a: partial congenital block vertebra of C2-C3 (arrow)
  • b: complete congenital block vertebra consisting out of 3 vertebrae (arrows).
  • AP diameter: = in a, < in b
  • Height: = expected sum in a, < expected sum in b
ACQUIRED VERTEBRAL FUSION: SEQUELAE OF INFECTIOUS SPONDYLODISCITIS

BACKGROUND
- Late complication of infectious spondylodiscitis
- Height: < sum of 2 vertebrae and intervertebral disc

IMAGING CASE

patient with a history of tuberculous spondylodiscitis

- Sagittal T1W MRI and CT:
  - L2-L3: vertebral fusion (dotted line) after destruction of the vertebrae and intervertebral disc
  - Protrusion of the remainder of the anterior corner of L3 mimics a plump syndesmophyte (short arrow)
  - L5-S1: partial vertebral fusion after destruction, mimicking transdiscal ankylosis as seen in SpA
ACQUIRED VERTREBRAL FUSION: POST-TRAUMATIC

BACKGROUND

• Post-traumatic interbody fusion:
  • Rare phenomenon
  • Occurs when both opposing endplates and intervertebral disc are involved

IMAGING CASE

patient with history of severe spinal trauma several years ago

• Sagittal T1W MRI:
  • Interbody vertebral fusion
  • Remnants of intervertebral space (arrows)
  • Height: < expected sum
  • AP diameter: preserved
CONCLUSIONS
CONCLUSIONS

MRI OF THE SACROILIAC JOINTS
• Examine the joint space on T1W MRI for high signal intensity (‘backfill’) or ankylosis, as these signs are very specific for SpA

MRI OF THE SPINE
• Examine the intervertebral joint space and disc on T1W MRI for discal high signal intensity or ankylosis (i.e. vertebral corner bridging or transdiscal ankylosis) as these signs are also very specific for SpA
• Beware non-bridging syndesmophytes on MRI, this finding at MRI is neither sensitive nor specific for SpA
• Inspection of the facet joints and manubriosternal joint can reveal under-appreciated features of SpA

BEWARE THE PITFALLS
• DISH, sequelae of infectious spondylodiscitis, congenital block vertebra or post-operative vertebral fusion also show or mimic new bone formation
REFERENCES