Discover the Clinical Significance of Upright Weight-Bearing MRI

Rotate the bed from recumbent to upright and compare MRI scans in different patient positions.

Acquire MRI scans in both flexion & extension positions since there is nothing in front of the patient’s face.

Weight-Bearing MRI
Multi-Position MRI

FONAR Corporation
110 Marcus Drive, Melville, NY, 11747
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There is considerable evidence that the **Upright Weight-Bearing MRI** provides medical benefits that are not duplicated by any other MRI.

- **Patient positioning plays a critical role in detecting clinically significant pathology.**
- **Recumbent-only imaging can underestimate the maximum degree of pathology.**
- **Peer-reviewed publications demonstrate the impact on treatment.**

The **Upright Weight-Bearing MRI** actually does something clinically valuable that a high-field MRI cannot do!

Yes, we offer exceptional patient comfort, but *this* MRI is *not just* for claustrophobic patients.
“So do you have good images?”
Why an upright, weight-bearing MRI scan?

An examination of the spine in the seated or upright position is important because the spine changes under the effects of both gravity and position.

The high-field MRIs may not show the abnormalities which account for symptoms experienced while in a seated, standing, extending, flexing or lateral bending position.

A patient’s hips and knees are often flexed and the knees supported by a pillow to take the strain off the back in order to help the patient lie down in a traditional high-field MRI. This is an unnatural position and not at all optimized to visualize the cause of spinal pathology for which symptoms are often experienced when sitting or standing.

Finally, many patients with spinal issues are not able to lie down without experiencing pain.
Let’s review some **Clinical Case Studies**

You need the upright position to see the **pathology highlighted in red**.

Each box compares the **same** patient in **different** positions on the **same** day in the **same** MRI scanner.
What happens when we stand or sit upright?

A. Nachemson, MD in *SPINE* (1976) reported on measuring the **significant increase in disc pressure** when the patient is not lying down.
You need the **upright weight-bearing position** to see the pathology highlighted in red.

**Position-dependent disc herniation**

*Case Courtesy of FW Smith, MD University of Aberdeen, UK*
You need the **upright weight-bearing position** to see the pathology highlighted in red.

*Case Courtesy of M Rose, MD  Tampa, FL*

**Post-operative spinal instability** in a patient with recurrent low back pain following a fusion from L4 to S1.
An unsuspected anterolisthesis at L3/4 in a patient with prior L4-S1 fusion changed the patient management from conservative treatment to ligament stabilization at the level above (i.e., at L2/3).

**Positional alterations** include anterior displacement of the upper cauda equina against the posterior surface of a protruding disc at L1/2.

You need the **upright weight-bearing position** to see the pathology highlighted in red.
The increased downward herniation of the cerebellar tonsils required neurosurgery to eliminate the patient’s drop attacks.

The upright CSF flow image shows an unobstructed dorsal CSF flow (black arrow) but demonstrates the obstruction of ventral CSF flow.

You need the upright weight-bearing position to see the pathology highlighted in red.
“The dominant motions at both the lower cervical and entire lumbar spine, where most clinical pathology occurs, are flexion-extension”

~ AMA Guides to the Evaluation of Permanent Impairment ~
In extension, the anterior longitudinal ligament becomes taut, and the posterior longitudinal ligament becomes lax ... so a disc with internal derangement that fluctuates will tend to move posteriorly.

Additional disc herniation at C4/5

You need the extension position to see the pathology highlighted in red.
You need **flexion, extension and lateral bending** to see the pathologies highlighted in red.

Dynamic fluctuation of spinal neural foramen stenosis showing **narrowing of the neural foramen at L5/S1 in extension** and generalized widening in flexion at all levels.

This **spinal instability** is best visualized with upright lateral bending.

Ligamentous rupture at L4/5

Cases courtesy of FW Smith, MD, University of Aberdeen, UK
Hard-to-Scan Patients

Patients that are unable to lie down.

*Kyphosis*

Cases Courtesy of FW Smith, MD University of Aberdeen, UK
Pediatric MRI: No sedation

A child sitting on his mother’s lap watching the television during his spine MRI scan.
More Consequences of Gravity: *It’s Not Just for the Spine*

Case Courtesy of P Barrance, PhD
University of Delaware

- **Tibial Subluxation**
- **Bladder & Uterine Prolapse**

(Upright and Recumbent images)
Twenty-five (25) chronic low back pain patients with prior “negative” recumbent-only MRIs …

What percentage showed abnormalities in one or more of the upright positions, and still nothing in their recumbent position?
Twenty-five (25) chronic low back pain patients with prior “negative” recumbent-only MRIs …

What percentage showed abnormalities in one or more of the upright positions, and still nothing in their recumbent position?

So What?

Each of these patients had surgery and six months later they remain symptom-free.
“Positional Upright Imaging of the Lumbar Spine Modifies the Management of Low Back Pain and Sciatica”
52% of a group of 25 chronic low back pain patients with prior “negative” recumbent-only MRIs demonstrated abnormalities in one or more seated postures “that were not evident in the recumbent position, and each of these patients has undergone appropriate surgery and 6 months post-surgery they remain symptom-free.”
FW Smith MD et.al., Dept. of Radiology, University of Aberdeen, UK

“Dynamic Weight-Bearing Cervical Magnetic Resonance Imaging: Technical Review and Preliminary Results”
Neurosurgeons examining 20 patients with symptoms consistent with cervical radiculopathy or myelopathy concluded that “when only static supine MRI is performed ... the true abnormality may be overlooked and inappropriate surgical plans instituted because of a lack of illustration of the changes that occur with movement.”
T Vitaz MD et.al., Dept. of Neurosurgery, University of Louisville, KY
In a study of 553 patients with symptomatic back pain, in those with normal or less than a 3 mm bulge in the neutral position, 19% demonstrated an increase in herniation to greater than 3 mm in extension. Further, 15% demonstrated an increase in herniation to greater than 3 mm in flexion.

J. Zou, M.D. et al., Department of Orthopedic Surgery, UCLA

“... there is no doubt that clinically relevant spinal canal stenosis can be uncovered by imaging the erect position. In cases where conventional MRI shows no evidence of cauda equina or lumbar nerve root compression in the setting of convincing clinical symptoms that warrant surgical intervention, re-imaging in the upright position, with the addition of flexion and extension, is recommended.”

F. Alyas, et. al., Dept. of Radiology, Royal National Orthopaedic Hospital NHS Trust, Stanmore, Middlesex, UK
“A Case-Controlled Study of Cerebellar Tonsillar Ectopia (Chiari) and Head/Neck Trauma (Whiplash)”

A multi-center study of 1200 patients with neck pain showed recumbent MRI underestimates the incidence of herniated cerebellar tonsils. The incidence of tonsillar herniation in non-traumatic neck pain patients was about the same, 5.3-5.7%, for both recumbent and upright positions, while in whiplash patients, 23.3% examined upright showed herniation of the cerebellar tonsils, whereas only 9.3% examined recumbent showed this abnormality.

M Freeman et al., Oregon University School of Medicine, Univ. of Aarhus, Univ. of Aberdeen, Spinal Injury Foundation, Columbia Univ., Univ. of Nebraska, Wisconsin Chiari Center

The Spine Journal (2007) Volume 7, Number 5S  
“Missed Spondylolisthesis in Static MRIs But Found in Dynamic MRIs in Patients with Low Back Pain”  S.W. Hong, M.D. et al., UCLA  
“In [510] patients with back pain, missed spondylolisthesis in neutral MRIs but found in flexion MRIs is 18.1% for all the levels if the spondylolisthesis is considered as more than 3 mm translation.”
What’s the Clinical Relevance?

Peer-reviewed Scientific Publications: Effects on Patient Treatment

Journal of Orthopaedic Research 23 (2005) “Patellofemoral Joint Contact Area Increases with Knee Flexion and Weight-bearing Conditions”

Orthopedic surgeons concluded that “patellofemoral joint contact areas should be measured under loaded conditions ... when trying to understand potential mechanisms of patellofemoral pain” to account for cartilage deformation and changes in patellar alignment. TF Beiser MD et.al., Stanford University


Radiologists reported that “weight-bearing imaging of the forefoot ... demonstrated position-related changes of the neurovascular bundles relative to the metatarsal heads ...” D Weishaupt MD et.al., University of Zurich, Switzerland

WomansImagingOnline (2007) “Pelvic Floor Dysfunction”

A radiologist concludes that “the main drawback of MRI is supine imaging that can limit the dynamic component of the examination … upright scanners may ultimately lead to MRI being the one imaging test for PFD.” H Pannu MD, Johns Hopkins University
Concerned about the Upright MRI’s 0.6 Tesla magnetic field strength?

Compare these images from the same patient, same day, same imaging center

**3.0 Tesla**
- 3:51 scan time
- 22 slices
- 5.0 mm thick
- 23 cm FOV

**Upright® MRI 0.6 Tesla**
- 5:03 scan time
- 24 slices
- 5.0 mm thick
- 25 cm FOV

**Upright® MRI 0.6 Tesla**
- 4:41 scan time
- 24 slices
- 5.0 mm thick
- 25 cm FOV

**3.0 Tesla**
- 1:30 scan time
- 30 slices
- 4.0 mm thick
- 23 cm FOV
3DFT Clinical Case Study: Whole Head

(3DFT SSFP-FID GRE) 6:45 scan time, 320 slices, 1.5 mm thick, no gap (0.75 mm slice overlap)

1.5 mm thick slices
3DFT Clinical Case Study: Whole Head

Reformat into 252 slices
No additional scan time
3DFT Clinical Case Study: Whole Head

Reformat into 360 slices
No additional scan time
Clinical 3DFT: **Weight-Bearing Kneeling Knee**

(3DFT SSFP-FID GRE) 5:04 scan time, 224 slices, **2.0 mm** thick, no gap (0.75 mm slice overlap)
Clinical 3DFT: Weight-Bearing Kneeling Knee

Reformat into 360 slices
No additional scan time
Clinical 3DFT: Upright Weight-Bearing **MRI Scoliosis Evaluation**

Standing Rapid MRI with Sagittal Multi-planar Reconstruction (SMMR)

- 0.5 mm isotropic voxels
- Curved MPR
- Cobb angle calculation
- T7 rotation

This example of an Upright MRI Scoliosis examination courtesy of Stand-Up MRI of Melville

**IMAST (2009) Vienna 16th International Meeting on Advanced Spine Techniques**

“Evaluation of Scoliosis with Standing Rapid MRI with SMMR: An Alternative to Plain Radiography” Q. Hammouri, J. Grauer et. al. **Yale Univ. School of Medicine**

Ten subjects (10-18 years) who had undergone radiographic imaging for idiopathic scoliosis were also evaluated using a rapid upright MRI with SMMR ... “Scoliosis may now be accurately and reliably quantified using MRI technology, thereby decreasing radiation exposure and its inherent risks.”
Fat Suppression

**STIR**

**Water-Fat Separation**

**Direct FatSat**

**Knee**

**Shoulder**

**Orbits**

**Spine**
So is our 0.6 Tesla magnetic field strong enough?

✓ The Upright MRI is **twice as strong** as most Open MRIs.

✓ The Upright MRI has a competitive advantage for post-operative patients since *artifacts from metal surgical screws diminish* as the MRI’s field strength is reduced.

✓ The Upright MRI is **dramatically different from an Open MRI** because physics allows the Upright MRI to use the same RF receiver coil as a high-field MRI to image the spine. The Open MRI is unable to do this.

✓ The position-dependent pathology we detect will be invisible or underestimated at higher field strengths … *sometimes patient positioning trumps a small increase in resolution or a small decrease in scan time.*
Images from the Same Patient at Different Field Strengths

Compared to the high-field (1.5 T) MRI scan on the far right, the structures in and around anatomy adjacent to the implanted titanium pedicle screws are **less obscured** with the 0.6T Upright MRI.

The parasagittal slices show the pedicle screws used in a L4-S1 fusion **do not generate** a large metal artifact.

You can see the threads!
Rule of MRI: The axis of symmetry of the RF receiver coil should be perpendicular to the direction of the main magnetic field.
### More Competitive Advantages of the Upright Weight-Bearing MRI

<table>
<thead>
<tr>
<th>Magnet</th>
<th>RF Coil →</th>
<th>Planar (flat)</th>
<th>Solenoid (“belt”)</th>
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<tbody>
<tr>
<td></td>
<td>High-Field MRI</td>
<td>✓</td>
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<tr>
<td></td>
<td>Open MRI</td>
<td></td>
<td>✓</td>
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<tr>
<td></td>
<td>Stand-Up (Upright) MRI</td>
<td>✓</td>
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The Upright MRI can use the same type of RF receiver coil as a high-field MRI (i.e., planar configuration)

An Open MRI cannot do this, **so the Upright MRI is dramatically different than an Open MRI**
Misunderstanding Field Strength

“I must have the best images”

Possibly requires:

- Particular anatomical region
- Specific type of image contrast
- Demanding spatial resolution
- Extreme image clarity
- Artifact-free images
- Specialized imaging applications
- Different patient positions

Q: Why?

A: “I don’t want to miss anything”
So Don’t

THE FONAR Upright® MRI

The Upright Weight-Bearing MRI actually does something clinically valuable that a high-field MRI cannot do!

Sometimes, patient positioning \textit{trumps} a small increase in resolution or a small decrease in scan time.

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