Upright Positional MRI of the Lumbar Spine

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FROM ABSTRACT:

Supine magnetic resonance imaging (MRI) is routinely used in the assessment of low back pain and radiculopathy. However, imaging findings often correlate poorly with clinical findings. This is partly related to the positional dependence of spinal stenosis, which reflects dynamic changes in soft-tissue structures (ligaments, disc, dural sac, epidural fat, and nerve roots).

Upright MRI in the flexed, extended, rotated, standing, and bending positions, allows patients to reproduce the positions that bring about their symptoms and may uncover MRI findings that were not visible with routine supine imaging. Assessment of the degree of spinal stability in the degenerate and postoperative lumbar spine is also possible.

The aim of this review was to present the current literature concerning both the normal and symptomatic spine as imaged using upright MRI and to illustrate the above findings using clinical examples.

THESE AUTHORS ALSO NOTE:

Supine magnetic resonance imaging findings are often inaccurate because they are exposed in the supine patient position with hips and knees flexed, resulting in relative spinal flexion. “This maximizes the dimensions of the canal and exit foramina, thus reducing the magnitude of any stenotic effect.”

“Clinical symptoms can develop with sitting, standing, or dynamic maneuvers (including flexion and extension) and may not be adequately assessed by supine MRI.”

“Development of these symptoms reflects the morphological changes in normal or degenerate disco-ligamentous structures due to the effects of gravity, changes in size of the intervertebral foramen, and relative motion between adjacent vertebrae on assumption of the upright posture and with dynamic maneuvers.”

“Therefore, upright and dynamic imaging is important.”
Open MRI systems allow imaging under the influence of gravity in the upright position (seated or standing), and they also allow imaging while, in flexion, extension, lateral bending, rotation etc.

“Imaging in the physiologically representative upright position and with kinetic maneuvers, allows accurate assessment and measurement of changes in the relationship between the components of the functional spinal unit and the potential to correlate radiological signs with positional symptoms.”

This study shows how upright MRI can demonstrate changes from supine to the erect imaging and between-erect flexed and erect-extended positions in the normal, degenerate, and postoperative spine.

“On supine imaging, spinal alignment does not reflect the true postural effect of body weight, which can increase by 80%, and the action of paraspinal and abdominal musculature.” [Important]

“Disc degeneration results in a posterior annular tear. From the supine to the upright position, there is increasing compressive force on the disc as a result of gravity and muscle activation. Telescoping of the spine results in circumferential bulging of degenerate discs, and these changes increasing in a caudal direction.”

During extension, tension increases in the anterior longitudinal ligament, displacing the semi-liquid nucleus pulposus posteriorly. [Interesting]

Posterior disc bulges/herniations may also develop or increase in degenerate discs during flexion from weakness/dysfunction of the posterior longitudinal ligament and more extensive annular tears.

In normal subjects, on assumption of the erect from the supine position, there is a reduction in the cross-sectional area of the central canal and lateral recesses.

In symptomatic subjects, there is a reduction in the central canal cross sectional area from the supine to the upright extended position and from flexion to extension.

The smallest cross sectional area of the central neural canal is found in upright extension position.

“Complete loss of CSF around nerve roots on T2W images is a good sign of central canal stenosis and may be seen with dynamic extension and erect imaging.”

“Imaging in the supine position and with non-dynamic methods can only identify indirect radiological signs of instability (i.e., degenerative changes of the disc, ligaments, and facet joints) and some direct signs (malalignment of the vertebral bodies). Upright and positional MRI can demonstrate changes in
intersegmental motion that may correlate with clinical symptoms of LBP and neurogenic claudication.”

Instability can be considered as part of the normal degenerative process of the lumbar spine, which has three phases:

1) “Initially, there is abnormal motion of the spinal segment (disc, adjacent vertebrae, ligaments, facet joints) and pathological signs of degeneration are minimal; this stage being termed ‘spinal dysfunction’”. [Chiropractic Subluxation]

“The signs of relative spinal motion (e.g., translation and sagittal rotation of the vertebral bodies with respect to each other) can be uncovered with upright/positional MRI.”

2) The second or “instability phase.”
“Signs of degeneration are more prominent and there is increased and abnormal intersegmental movement. Instability can be demonstrated as relative hypermobility at the spinal motion segment compared with adjacent motion segments on positional MRI.”

“Excess extension can in turn increase the degree of foraminal, central and lateral recess stenosis, which may correlate with increased levels of pain.”

“The disc below a degenerate spinal level can be susceptible to degeneration and can be identified by increased degree of motion.”

“In the postoperative spine, damage to the paraspinal musculature and ligaments, and reduced motion at levels of fusion together with increased motion at the adjacent levels contribute to instability.”

3) Phase three:
“As degeneration progresses, fibrosis and osteophytosis result in re-stabilization and consequential reduction in movement.”

“Although the lower field strength of the system results in a reduced signal:noise ratio, and thus, overall reduced image quality compared with high-field magnets, we have found that image quality is certainly adequate for the demonstration of lumbar canal stenosis and nerve root compression. This fact outweighs the limitations of closed high-field systems, which to our knowledge, do not allow for any form of erect lumbar spinal imaging.”

CONCLUSIONS

“Conventional high-field MRI with the patient in the supine position is now widely available and remains the technique of choice for the investigation of degenerative lumbar spine disorders associated with lower limb symptoms.”
“However, there is no doubt that clinically relevant spinal canal stenosis can be uncovered by imaging in 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.”

**KEY POINTS FROM DAN MURPHY**

1) “Upright MRI in the flexed, extended, rotated, standing, and bending positions, allows patients to reproduce the positions that bring about their symptoms and may uncover MRI findings that were not visible with routine supine imaging.”

2) Upright dynamic MRI is superior in the assessment of spinal stability in the degenerate and postoperative lumbar spine.

3) Supine magnetic resonance imaging findings are often inaccurate because they are exposed in the supine patient position with hips and knees flexed, resulting in relative spinal flexion. “This maximizes the dimensions of the canal and exit foramina, thus reducing the magnitude of any stenotic effect.”

4) “Clinical symptoms can develop with sitting, standing, or dynamic maneuvers (including flexion and extension) and may not be adequately assessed by supine MRI.”

5) Open MRI systems allow imaging under the influence of gravity in the upright position (seated or standing), and they also allow imaging while, in flexion, extension, lateral bending, rotation etc.

6) “Imaging in the physiologically representative upright position and with kinetic maneuvers, allows accurate assessment and measurement of changes in the relationship between the components of the functional spinal unit and the potential to correlate radiological signs with positional symptoms.”

7) “On supine imaging, spinal alignment does not reflect the true postural effect of body weight, which can increase by 80%, and the action of paraspinal and abdominal musculature.” **[Important]**

8) During extension, tension increases in the anterior longitudinal ligament, displacing the semi-liquid nucleus pulposus posteriorly. **[Interesting]**

9) Posterior disc bulges/herniations may also develop or increase in degenerate discs during flexion from weakness/dysfunction of the posterior longitudinal ligament and more extensive annular tears.
10) Both central canal and lateral recess stenosis are best evaluated with upright imaging.

11) The smallest cross sectional area of the central neural canal is found in upright extension position.

12) “Complete loss of CSF around nerve roots on T2W images is a good sign of central canal stenosis and may be seen with dynamic extension and erect imaging.”

13) “Imaging in the supine position and with non-dynamic methods can only identify indirect radiological signs of instability (i.e., degenerative changes of the disc, ligaments, and facet joints) and some direct signs (malalignment of the vertebral bodies). Upright and positional MRI can demonstrate changes in intersegmental motion that may correlate with clinical symptoms of LBP and neurogenic claudication.”

14) Spinal instability has three phases:

A)) “Initially, there is abnormal motion of the spinal segment (disc, adjacent vertebrae, ligaments, facet joints) and pathological signs of degeneration are minimal; this stage being termed ‘spinal dysfunction’”. [Chiropractic Subluxation]

“The signs of relative spinal motion (e.g., translation and sagittal rotation of the vertebral bodies with respect to each other) can be uncovered with upright/positional MRI.”

B)) The second or “instability phase.”

“Signs of degeneration are more prominent and there is increased and abnormal intersegmental movement. Instability can be demonstrated as relative hypermobility at the spinal motion segment compared with adjacent motion segments on positional MRI.”

“Excess extension can in turn increase the degree of foraminal, central and lateral recess stenosis, which may correlate with increased levels of pain.”

“The disc below a degenerate spinal level can be susceptible to degeneration and can be identified by increased degree of motion.”

“In the postoperative spine, damage to the paraspinal musculature and ligaments, and reduced motion at levels of fusion together with increased motion at the adjacent levels contribute to instability.”

C)) Phase three:

“As degeneration progresses, fibrosis and osteophytosis result in re-stabilization and consequential reduction in movement.”
15) “Although the lower field strength of the system results in a reduced signal:noise ratio, and thus, overall reduced image quality compared with high-field magnets, we have found that image quality is certainly adequate for the demonstration of lumbar canal stenosis and nerve root compression. This fact outweighs the limitations of closed high-field systems, which to our knowledge, do not allow for any form of erect lumbar spinal imaging.”

16) “There is no doubt that clinically relevant spinal canal stenosis can be uncovered by imaging in the erect position.”

17) “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.”

18) “Upright and dynamic imaging is important.”

COMMENT FROM DAN MURPHY

My college, Life Chiropractic College West, [(510) 780-4500], has an upright, weight-bearing, dynamic MRI unit on campus. It is available for patient referral.