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# UPRIGHT MRI IN THE SEATED POSITION INCREASES INSIGHT INTO DEGENERATIVE DISC DISEASE

For the past twenty five years we have studied the lumbar spine, by MRI, in the supine position. This position is often the most comfortable for the patient, when in fact their symptoms are often worse when either standing or sitting. With the availability of an Upright MRI scanner in which images can be made in the erect position, a number of studies have been performed to examine the changes in the appearances of both healthy and abnormal discs in different postures. The differences in the appearances of the lumbar spine, abdomen and pelvic contents are very obvious as seen in figure 1



*SUPINE*

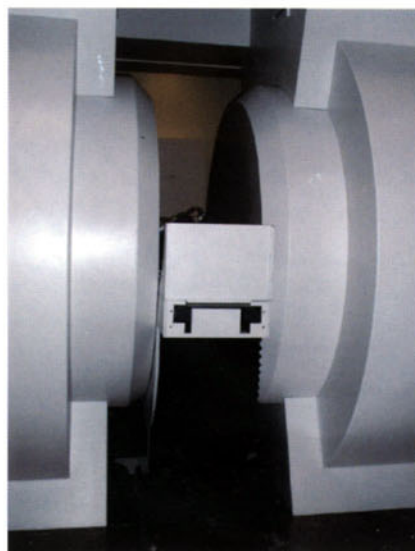


*SITTING ERECT*

*Figure 1*

## MRI SCANNER

The MRI system used for these studies has been designed specifically to image patients in both the erect and supine positions. The system operates at 0.6 Tesla utilising a resistive magnet with a horizontal field, transverse to the axis of the patient's body (FONAR, Melville New York). This provides a non-claustrophobic open view from the magnet, allowing for unimpeded patient movement studies. A unique MRI compatible, motorised patient handling system has been developed for the scanner, which allows for vertical (load bearing) to horizontal (supine) positioning of patients. Our system takes advantage of a 50 tilt in vertical studies to stabilise the patient and



*SUPINE*



*ERECT*

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**SEATED IN NEUTRAL**



**FLEXION**



**EXTENSION**

*Figure 2*

was used in all studies. The custom-built patient handling system allows for patients to be imaged; standing, sitting, lying supine, prone, or on their side, at any angle between vertical and 20° in the Trendelenberg position. Because of its “open” design, patients are able to move within the scanner enabling images to be made in flexion and extension, in addition to the normal neutral position. A seat attachment has been developed to allow imaging in the sitting position. Data is acquired using a flexible, solenoidal RF receiver coil. (Figure 2).

## STUDIES

The initial work with upright scanner concentrated on measuring the variations in the dimensions of the normal spinal canal, nerve root canals and intervertebral discs. In one study 29 male volunteers with no symptoms of low back pain. Age: 21 - 61 years (mean 32 years) were studied. The following observations were made, confirming the accepted knowledge as measured in cadaver studies.

1] We have shown a significant posture-dependent difference of the cross-sectional dural sac area at the intervertebral disc level in asymptomatic volunteers.

2] When changing posture from a supine to a standing position, the cross-sectional area of the dural sac increases.

3] The smallest cross-sectional dural sac area was found in the supine position.

4] The dural sac contour took the appearance of a longitudinal ellipse in flexion and a transverse ellipse in extension and that cross-sectional dural sac area did not change significantly at the L3/4 and L4/5 disc level<sup>(1)</sup>

In a further study, 32 male volunteers [Age 21 – 61 years, mean 32 years] were studied. The subjects were scanned in the vertical posture within 2 hours of arising and again in the evening. The disc heights were measured using the Dabbs method

- First ever MRI disc height study to investigate the spine in a true standing posture.
- There is a diurnal reduction in height at all lumbar disc levels.
- The time of day that the MRI scan was obtained influenced the height of the lumbar disc.
- In the erect posture, diurnal height loss is more pronounced at the lower disc levels.
- There is a detectable diurnal and postural variation in disc height. (2)

A number of studies have been performed to examine the differences in the appearances of the abnormal spine, in an effort to ascertain the potential for being able to scan in more than one position.

320 patients (163 males and 157 females) aged between 24 and 78 years (mean 57 years), suffering from low back pain and sciatica, have been scanned using the 0.6T “Upright” scanner. Each patient was imaged supine, standing erect, sitting and also seated in flexion and extension. Sagittal T2 and axial T2 weighted images were made through the lower three intervertebral discs in all 5 different postures

Of 960 discs examined 522 were considered to be normal. These “Normal discs” showed no significant change in disc height between supine and sitting. i.e. a reduction

in height anteriorly on forward flexion of 1-2mm and a similar reduction in height posteriorly on extension. 438 showed degenerative change in their nuclei, half of which behaved like normal discs and are considered to be normal and classified as degenerative change. The other half were classified as "Degenerate discs" showing 2-5mm change in disc height between supine and sitting and also a reduction of greater than 3mm in disc height on flexion and extension with varying degrees of disc prolapse. Thus by being able

to image the spine in both supine and erect positions we are able to differentiate between the "normal" aging disc that has a reduced signal from its nucleus and degenerate discs that show the same degenerative appearance but reduce in height when in the weight bearing position. 108 prolapsed discs showed reduction of posterior prolapse on forward flexion & increase in extension. Interestingly 23 showed the reverse.



*SUPINE*



*STANDING ERECT*



*SITTING FLEXED*



*SITTING NEUTRAL*



*SITTING EXTENDED*

*Figure 3. Fluctuating Spondylolisthesis.*



*SUPINE*



*STANDING ERECT*



**SITTING FLEXED**



**SITTING NEUTRAL**



**SITTING EXTENDED**

*Figure 4 Hypermobile discs. Note the change in appearances of the L4/5 & L5/S1 intervertebral discs between the five different postures. This patient had had three 'Normal' MRI scans prior to this examination.*

A further Twenty five patients referred for MRI of the lumbar spine following at least one prior, "normal" MRI examination within six months of referral have been reviewed. 14 men and 12 women aged between 38 and 67 years of age were examined. Each patient was scanned supine, standing erect and in the seated position as described above.

In twelve cases, no significant abnormality was seen in any of the five postures. In thirteen, abnormalities were demonstrated in one or more of the seated postures that were not evident in the conventional supine examination. In three cases lateral disc herniation was only seen in the seated position. In six cases the presence of a hypermobile disc at one or more level was demonstrated. In two cases previously unsuspected grade 1 spondylolisthesis was shown and in two cases significant spinal canal stenosis was seen in the seated extended position.

Thus in 50% of these cases who had previously been unsuccessfully investigated for sciatica, a surgically remediable lesion was found. Each of the thirteen patients has undergone appropriate surgery and six months after surgery remain symptom free.

The investigation of post operative pain is one which supine MRI does not often show a cause. To ascertain whether or not imaging in flexion and extension would be of value in assessing patients who returned with back pain

following either spinal fusion or ligament stabilisation a series of twelve patients referred for MRI of the lumbar spine for the investigation of post spinal operative pain have been reviewed. 7 men and 5 women aged between 40 and 72 years of age have been examined each patient was scanned supine, standing erect and in the seated position.

In four cases, no significant abnormality was seen in any of the five postures. In eight, abnormalities were demonstrated in one or more of the seated postures that were not evident in the conventional supine examination.

One patient following unilateral laminectomy and discectomy was found to have spinal instability secondary to damage to the interspinous ligament. (Figure 5) Three patients had undergone ligament stabilisation and four had had postero-lateral instrumented fusion of the lower lumbar spine. All seven showed varying degrees of hypermobility at the transitional intervertebral disc above the stabilisation/fusion level. (Figure 6). In one case this was so severe as to cause almost complete occlusion of the spinal canal in the flexed and extended positions.

This studies show that MRI in the upright position, together with the ability to image with the body flexed and extended aids diagnosis in over 50% of difficult to diagnose cases of spinal instability and demonstrates fluctuating degenerate discs that would otherwise go unrecognised.



SUPINE



SITTING



SITTING IN FLEXION

Figure 5. Post operative instability at the L4/5 level seen in association with a tear of the L4/5 interspinous ligament.



SUPINE



SITTING NEUTRAL



SITTING FLEXED



SITTING EXTENDED

Figure 6. 4 years after postero-lateral instrumented fusion of L4 to the sacrum there is disc degeneration and spondylolisthesis at the L3/4 level which is not evident in the supine position, but is clearly seen in the three seated positions.

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