# Upright MRI Lumbar Spine: A Comparison Among Foraminal, Disc, and Lumbar Alignment Parameters Between Symptomatic and Asymptomatic Patients

Brian D. Stemper PhD; Ha Nguyen MD; Jamie Baisden MD
Medical College of Wisconsin

## Introduction

Lumbar back pain and lumbar radiculopathy are common medical diagnoses that cause extensive economic burden. Unfortunately, conventional supine MRI findings and clinical symptoms do not necessarily correlate in the lumbar spine. While supine, the lumbar lordosis is physiologically reduced with relief or reduction in pain. Moreover, nerve root compression may not be visible with MRI performed in a supine position. With upright imaging, disc pathologies or foraminal stenosis may become more salient, leading to potential nerve root compression that is not visible on supine images.

## Methods

Seventeen adults (10 asymptomatic patients and 7 symptomatic patients) were selected. A 0.6 T upright MRI scanned each patient in the upright position. Parameters were obtained from the L2/3 level to L5/S1 level, including those pertaining to the foramen (cross sectional area, height, mid-disc width, width, thickness of ligamentum flavum), the disc (bulge, height), and lumbar alignment (lordosis angle, wedge angle, lumbosacral angle, lumbar spine length). Findings were compared via pair t tests between symptomatic patients and asymptomatic patients.

**Table 1: Patient demographics**

| | Asymptomatic | Symptomatic |
|---|---|---|
| Total | 10 | 7 |
| Males | 5 | 5 |
| Females | 5 | 2 |
| Age (years) | 25.22 | 35.14 |
| Height (cm) | 170.06 | 178.83 |
| Weight (kg) | 89.77 | 81.27 |

**Table 2: Foraminal parameters**

| | | Asymptomatic | stdev | Symptomatic | stdev | p value |
|---|---|---|---|---|---|---|
| Foramen mid disc width | L2/L3 | 4.828 | 2.035 | 5.469 | 2.956 | 0.459 |
| | L3/L4 | 4.409 | 1.654 | 4.616 | 1.594 | 0.718 |
| | L4/L5 | 4.383 | 1.489 | 4.355 | 1.399 | 0.956 |
| | L5/S1 | 5.843 | 2.140 | 4.857 | 2.072 | 0.190 |
| Foramen disc width | L2/L3 | 7.678 | 1.019 | 8.628 | 1.782 | 0.057 |
| | L3/L4 | 8.614 | 1.230 | 9.432 | 2.224 | 0.179 |
| | L4/L5 | 8.288 | 1.528 | 9.241 | 1.855 | 0.111 |
| | L5/S1 | 7.438 | 1.513 | 8.781 | 2.782 | 0.079 |
| Foramen height | L2/L3 | 18.809 | 1.883 | 19.936 | 4.706 | 0.339 |
| | **L3/L4** | **18.160** | **1.694** | **19.785** | **2.405** | **0.027*** |
| | L4/L5 | 16.493 | 1.546 | 15.513 | 5.051 | 0.419 |
| | L5/S1 | 14.699 | 4.866 | 15.783 | 5.758 | 0.557 |
| Foramen CSA | L2/L3 | 106.809 | 22.722 | 112.685 | 53.902 | 0.975 |
| | L3/L4 | 117.508 | 32.631 | 99.897 | 25.862 | 0.237 |
| | L4/L5 | 98.887 | 26.040 | 80.598 | 24.988 | 0.064 |
| | **L5/S1** | **104.463** | **23.801** | **82.708** | **30.129** | **0.036*** |
| TLF | **L2/L3** | **1.520** | **0.677** | **2.182** | **0.894** | **0.019*** |
| | **L3/L4** | **1.495** | **0.563** | **2.056** | **0.660** | **0.014*** |
| | **L4/L5** | **1.854** | **0.827** | **2.536** | **0.999** | **0.041*** |
| | **L5/S1** | **1.676** | **0.813** | **2.513** | **0.683** | **0.004*** |

**Table 3: Disc parameters**

| | | Asymptomatic | stdev | Symptomatic | stdev | p value |
|---|---|---|---|---|---|---|
| Disc bulge | L2/L3 | 1.141 | 0.516 | 1.289 | 0.657 | 0.467 |
| | L3/L4 | 1.036 | 0.359 | 1.264 | 0.762 | 0.250 |
| | **L4/L5** | **1.180** | **0.530** | **1.770** | **0.522** | **0.003*** |
| | **L5/S1** | **0.879** | **0.321** | **1.819** | **0.754** | **0.000*** |
| Disc height | L2/L3 | 6.795 | 1.270 | 7.159 | 1.520 | 0.459 |
| | L3/L4 | 7.814 | 1.587 | 8.223 | 1.715 | 0.485 |
| | L4/L5 | 7.590 | 1.171 | 7.805 | 2.330 | 0.729 |
| | L5/S1 | 6.229 | 1.167 | 6.720 | 1.409 | 0.282 |

**Table 4: Alignment parameters**

| | | Asymptomatic | stdev | Symptomatic | stdev | p value |
|---|---|---|---|---|---|---|
| Wedge angle | L2/L3 | 2.797 | 1.631 | 3.019 | 2.668 | 0.834 |
| | L3/L4 | 5.683 | 2.968 | 5.437 | 3.165 | 0.872 |
| | L4/L5 | 7.137 | 2.322 | 4.860 | 2.502 | 0.073 |
| | L5/S1 | 7.898 | 6.554 | 6.713 | 3.774 | 0.674 |
| Lumbar lordosis | | 50.161 | 10.530 | 40.861 | 13.239 | 0.127 |
| Lumbosacral angle | | 38.531 | 10.687 | 30.076 | 7.747 | 0.095 |
| Lumbar spine length | | 172.760 | 10.580 | 177.836 | 11.194 | 0.357 |

## Results

Among foramen parameters, the foramen height was statistically larger at the L3/4 disc space for the symptomatic group; the thickness of the ligamentum flavum was statistically larger along all disc space levels in the symptomatic group. The foramen cross sectional area was statistically smaller at the L5/S1 level in the symptomatic group. Among disc parameters, the disc bulge was significantly larger at L4/5 and L5/S1 in the symptomatic group. There were no significant findings among the lumbar alignment parameters.

## Conclusions

This supports the significance of ligamentum flavum hypertrophy as a component of these symptoms. Moreover, symptomatic patients have larger disc bulge and smaller foramen cross sectional area at the lower lumbar levels. Given these findings, upright MRI may be useful to evaluate and treat symptomatic patients.

### Learning Objectives

1) Understand the background on upright MRI
2) Understand the potential usefulness of upright MRI for diagnosing lumbar pathologies based on differences in various parameters seen between symptomatic patients and asymptomatic patients.

### References

1.Froud, R., et al., A systematic review and meta-synthesis of the impact of low back pain on people's lives. BMC Musculoskelet Disord, 2014. 15: p. 50.
2.Hahne, A.J., J.J. Ford, and J.M. McMeeken, Conservative management of lumbar disc herniation with associated radiculopathy: a systematic review. Spine (Phila Pa 1976), 2010. 35(11): p. E488-504.
3.Hoy, D., et al., The Epidemiology of low back pain. Best Practice & Research Clinical Rheumatology, 2010. 24(6): p. 769-781.
4.Splendiani, A., et al., Occult neural foraminal stenosis caused by association between disc degeneration and facet joint osteoarthritis: demonstration with dedicated upright MRI system. Radiol Med, 2014. 119(3): p. 164-74.
5.Balague, F., et al., Non-specific low back pain. Lancet, 2012. 379(9814): p. 482-91.
6.Tarulli, A.W. and E.M. Raynor, Lumbosacral radiculopathy. Neurol Clin, 2007. 25(2): p. 387-405.
7.Hedberg, K., et al., Low back pain: an assessment using positional MRI and MDT. Man Ther, 2013. 18(2): p. 169-71.
8.Weishaupt, D., et al., Positional MR imaging of the lumbar spine: does it demonstrate nerve root compromise not visible at conventional MR imaging? Radiology, 2000. 215(1): p. 247-53.
9.Gilbert, J.W., et al., Lumbar stenosis rates in symptomatic patients using weight-bearing and recumbent magnetic resonance imaging. J Manipulative Physiol Ther, 2011. 34(8): p. 557-61.
10.Iwata, T., et al., In vivo measurement of lumbar foramen during axial loading using a compression device and computed tomography. J Spinal Disord Tech, 2013. 26(5): p. E177-82.
11.Schmid, M.R., et al., Changes in cross-sectional measurements of the spinal canal and intervertebral foramina as a function of body position: in vivo studies on an open-configuration MR system. AJR Am J Roentgenol, 1999. 172(4): p. 1095-102.
12.Zamani, A.A., et al., Functional MRI of the lumbar spine in erect position in a superconducting open-configuration MR system: preliminary results. J Magn Reson Imaging, 1998. 8(6): p. 1329-33.

"For additional references, please contact hsnguyen@mcw.edu