Original Article

DOI: 10.7860/IJARS/2018/30862:2366

Radiology Section

# New Magnetic Resonance Imaging Grading System for Lumbar Neural Foramina Stenosis

BINOJ VARGHESE V, ARUN C BABU


## ABSTRACT

**Introduction:** Lumbar spine Magnetic Resonance Imaging (MRI) is the most frequently performed MRI procedure. Radiologist's reporting on qualification of lumbar neural foramen stenosis varies considerably, as there is no widely accepted grading system. We formulated a new MRI grading system comprising three grades of stenosis and normal foramen.

**Aim:** To evaluate the reliability of new grading system for lumbar neural foramina stenosis.

**Materials and Methods:** This descriptive study was conducted in the Department of Radiology at Tertiary Care Hospital in mid Kerala, South India between the period of April 2016 to June 2016. The four grades of the new grading system are based on sagittal MRI, relying T1WI. Grade 0 refers to normal neural foramen; Grade 1 refers to mild foraminal stenosis without perineural fat obliteration; Grade 2 refers to moderate foraminal stenosis showing partial perineural fat obliteration and Grade 3 refers to severe foraminal stenosis showing effacement of perineural fat or nerve root compression. We evaluated 762 neural foramina of 127 consecutive patients aged above 50 years with diagnosis of degenerative disc disease after MRI of the lumbar spine. Two general Radiologists independently graded L3/4, L4/5 and L5/S1 neural foramina in MRI studies, using the new grading system. One radiologist regarded neural foramina after one month, blinded to all previous grading. Interobserver agreement between the two radiologists and intraobserver agreement of one radiologist for new grading system was calculated using kappa statistics.

**Results:** Overall inter-rater and intra-rater agreements ($\kappa$) for new grading system are 0.836 (range: 0.771 to 0.906) and 0.947 (range: 0.907-0.969) respectively.

**Conclusion:** New grading system is optimal for routine radiologic reporting, as it is simple and reproducible.


**Keywords:** Low back pain, Nerve root compression, Perineural fat obliteration, Radiculopathy, Wildermuth system

## INTRODUCTION

Lumbar neural foraminal stenosis is a common finding in MRI of older patients, performed for suspected lumbar degenerative disc disease. The prevalence estimated using sagittal MRI is about 48% in a symptomatic group of average age 70 years [1]. The etiology is multifactorial involving osteophytes, disc bulges/herniation, ligamentum flavum hypertrophy and facet joint arthrosis [2-4]. The qualification of neural foramen stenosis varies considerably among radiologists due to the differing subjective criteria. Even though there are two existing MRI grading systems for LNFS, the Lee S et al., [1] system is complex and Wildermuth S et al., system [5] is partially incomplete. We propose a new grading system by modifying the Wildermuth system, for daily radiological reporting. The aim of this study is to analyse the reliability of the new grading system.

## MATERIALS AND METHODS

We designed the study as descriptive study and Institutional Review Board approved the project protocol. Informed consent was not required for this MRI analysis.

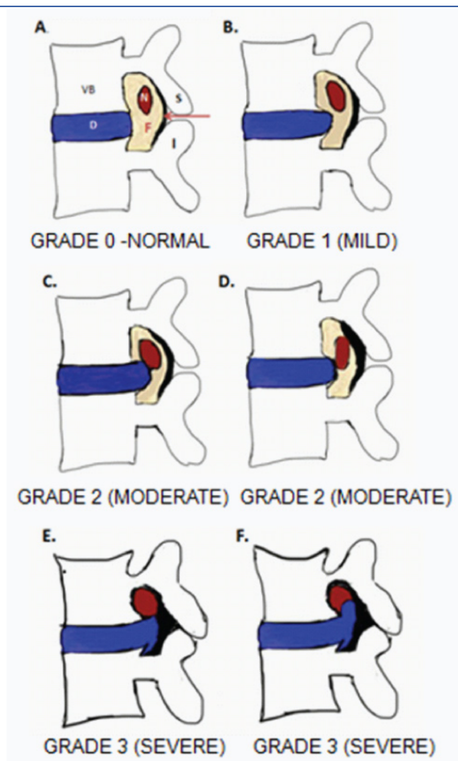
All consecutive 312 patients were selected, who had undergone standard protocol lumbar spine MRI in our Radiology Department (Tertiary care hospital in mid Kerala, South India) from April 2016 to June 2016. Total 185 patients were excluded based on age below 50 years, spinal infections, acute spinal trauma, or spinal malignancy in MRI. We included 127 patients in the analysis and retrieved the imaging and basic demographic data from the picture archiving and communication system. The average age of study population was 62.3±8.4 and comprised 58 (45.7%) males and 69 (54.3%) females.

MRI examinations were performed on a 1.5-T scanner (GE Signa HDxt, GE Healthcare, United States) in the supine position under standard lumbar spine protocol. The sagittal T1-WI and T2-WI (15 slices, slice thickness 4 mm with interslice gap 0.5 mm, and field of view 30-32 cm) were reviewed for grading.

Two general radiologists independently graded all 762 neural foramina at L3/4, L4/5, and L5/S1 using the new grading system. One radiologist regarded neural foramina after one month, blinded to all previous grading.

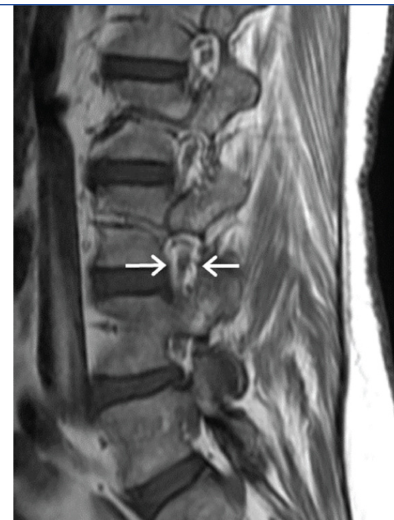
## New MRI Grading System for Lumbar Neural Foramina Stenosis Based on Sagittal Standard MRI Protocol

Grade 0- refers normal neural foramen (normal dorsolateral border of the intervertebral disc, normal form of epidural fat,




**[Table/Fig-1a-f]:** Diagrammatic illustration for grading of neural foraminal stenosis in sagittal T1 MRI of lumbar spine shows relationships of structures: a) showing the normal dimensions and form of perineural fat; b) showing bulging disc partially effaces the foraminal fat, but the perineural fat is preserved; c) showing bulging disc effaces perineural fat on one side and abuts the nerve root; d) showing bulging disc and ligamentum flavum hypertrophy efface perineural fat on two sides and abut the nerve root; e) showing bulging disc , ligamentum flavum hypertrophy and osteophyte efface the perineural fat completely, but there is no nerve compression; f) showing the nerve root compression by the bulging disc against the vertebral margin and thin rim of perineural fat on the posterior aspect of nerve root (arrow).

*Note- nerve root= N (red), perineural fat=F (orange), vertebral body=VB, intervertebral disk=D (blue), Ligamentum flavum (arrow), superior articular process= S, inferior articular process= I.



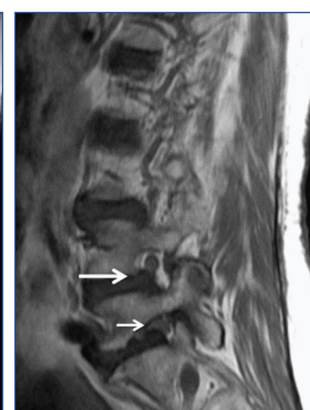
**[Table/Fig-2]:** Grade 0-neural foramen- T1W sagittal image of a 57-year-old woman shows the right L3-4 neural foramen (arrow). Note the normal dimensions of neural foramen and perineural fat.

no significant ligamentum flavum hypertrophy or facet joint arthrosis or osteophytes from foraminal margin [Table/Fig-1,2].

Grade 1- refers to mild foraminal stenosis with partial effacement of epidural fat, but perineural fat of exiting nerve root is preserved [Table/Fig-1,3].

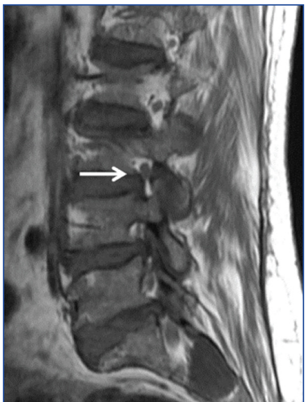
Grade 2- refers to moderate foraminal stenosis showing partial perineural fat obliteration [Table/Fig-1,4,5].

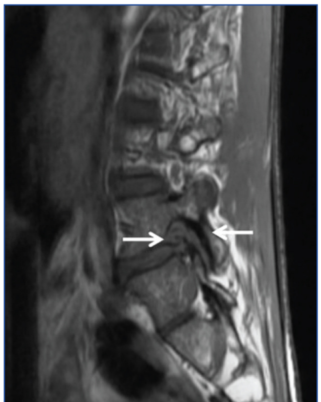
Grade 3- refers to severe foraminal stenosis showing circumferential effacement of perineural fat or nerve root compression [Table/Fig-1,6,7].



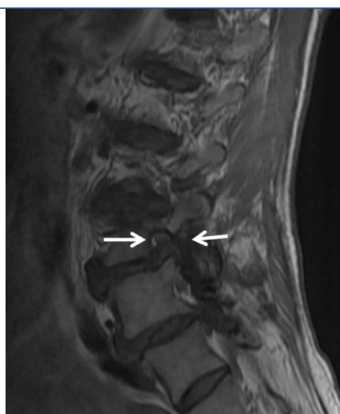
**[Table/Fig-3]:** (Left) Grade 1- neural foramen (mild ) stenosis. T1W sagittal image of a 70-year-old woman shows mild stenosis of the right L3-4 and L4-5 neural foramen (arrows). Note the bulging posterolateral margin of disc narrows the foramen with partial effacement of foraminal fat. Perineural fat is preserved.

**[Table/Fig-4]:** (Right) Grade 2 (moderate) neural foramen stenosis. T1W sagittal image of a 68- year-old woman shows the right L4-5 neural foramen (large arrow). Note the bulging disc abutting the nerve root with partial effacement of perineural fat. Also note grade 3 stenosis (small arrow) of L5-S1 neural foramen- the nerve root is compressed between the bulging disc and pedicle.





**[Table/Fig-5]:** (Left) Grade 2 (moderate) neural foramen stenosis. T1W sagittal image of a 74-year-old woman shows the right L3-4 neural foramen (arrow). Note the nerve root abutting the bulging disc and ligamentum flavum with effacement of perineural fat on two sides. **[Table/Fig-6]:** (Right) Grade 3 neural foramen stenosis. T1W sagittal image of a 44 year-old male shows the right L4-5 neural foramen (arrows). Note the bulging disc, osteophyte and ligamentum flavum hypertrophy causing complete effacement of perineural fat.



**[Table/Fig-7]:** Grade 3-neural foramen stenosis. T1-weighted sagittal image of a 73-year-old male shows the left L4-5 neural foramen (arrows). Note the bulging disc compresses and flattens the nerve root against the pedicle. Perineural fat can be seen at the anterior aspect of nerve.

## STATISTICAL ANALYSIS

The data obtained were entered into the excel spreadsheet and analysed using Statistical Package for the Social Sciences for Windows (SPSS 16.0). We estimated the inter-observer agreement between the two radiologists (radiologist 1 separately with first and second grading of radiologist 2) and intra observer agreement of radiologist 2, for the new grading system using kappa statistics. The kappa values between observers interpret as less than 0.21 denoting slight agreement; 0.21-0.40, fair agreement; 0.41-0.60, moderate agreement; 0.61-0.80, substantial agreement; and 0.81-1.00, almost perfect agreement [6,7].

## RESULTS

In this study, 127 patients with diagnosis of degenerative disc disease after MRI of the lumbar spine were evaluated. [Table/Fig-8] shows the frequencies of Lumbar Neural Foramen Stenosis (LNFS) using the new grading system.

| Observer | Neural foramen | Grade 0 | Grade 1 | Grade 2 | Grade 3 |
|---|---|---|---|---|---|
| Radiologist 01 | Right L3-4 | 4 | 71 | 51 | 1 |
| | Right L4-5 | 1 | 48 | 75 | 3 |
| | Right L5-S1 | 39 | 43 | 35 | 10 |
| Radiologist 02 | Right L3-4 | 3 | 74 | 49 | 1 |
| | Right L4-5 | 1 | 44 | 79 | 3 |
| | Right L5-S1 | 40 | 40 | 37 | 10 |
| Regrading by Radiologist 02 after two weeks | Right L3-4 | 2 | 74 | 50 | 1 |
| | Right L4-5 | 0 | 47 | 77 | 3 |
| | Right L5-S1 | 39 | 44 | 34 | 10 |
| Radiologist 01 | Right L3-4 | 10 | 78 | 38 | 1 |
| | Right L4-5 | 3 | 57 | 65 | 2 |
| | Right L5-S1 | 45 | 45 | 30 | 7 |
| Radiologist 02 | Right L3-4 | 7 | 80 | 39 | 1 |
| | Right L4-5 | 2 | 55 | 67 | 3 |
| | Right L5-S1 | 45 | 46 | 29 | 7 |
| Regrading by Radiologist 02 after two weeks | Right L3-4 | 7 | 80 | 39 | 1 |
| | Right L4-5 | 2 | 56 | 66 | 3 |
| | Right L5-S1 | 47 | 41 | 32 | 7 |

**[Table/Fig-8]:** Frequency of lumbar neural foramen stenosis using new system.

The inter and intraobserver agreements (kappa statistics κ) for each neural foramina are given in [Table/Fig-9].

There is almost perfect intra observer agreement (mean value 0.947, range 0.907-0.969) and substantial to almost perfect inter observer agreement (mean value 0.836, range 0.771-0.906). There were six instances (0.2%) of difference of two grades and 180 instances (7.87%) of difference of single grade of neural foramen stenosis between the observers.

## DISCUSSION

Neural foramen is the space between two pedicles, where the nerve exits the spinal canal. This should be differentiated from lateral recess, as a space below the disc level, where the nerve traverses laterally towards the foramen. The neural foramen stenosis can vary from mild foraminal space narrowing to complete obliteration of perineural fat and nerve root compression. The correlation of findings with symptoms is poor. Most surgeons consider LNFS as a contributing cause to radiculopathy in degenerative spinal stenosis. Laterally bulging annulus or herniated disc, ligamentum flavum hypertrophy, osteophytes from vertebral margins, disc space narrowing, spondylolisthesis and facet joint hypertrophy cause neural foramina stenosis. Documentation of nerve root compression

| | Right L3/4 | Right L4/5 | Right L5/S1 | Left L3/4 | Left L4/5 | Left L5/S1 |
|---|---|---|---|---|---|---|
| Radiologist 1 Vs Radiologist 2 F | 0.863 p=0.0001 | 0.906 p=0.0001 | 0.823 p=0.0001 | 0.848 p=0.0001 | 0.868 p=0.0001 | 0.806 p=0.0001 |
| Intra-rater Radiologist 2 | 0.907 p=0.0001 | 0.952 p=0.0001 | 0.956 p=0.0001 | 0.969 p=0.0001 | 0.956 p=0.0001 | 0.943 p=0.0001 |
| Radiologist 1 and Radiologist 2 S | 0.771 p=0.0001 | 0.859 p=0.0001 | 0.778 p=0.0001 | 0.848 p=0.0001 | 0.853 p=0.0001 | 0.818 p=0.0001 |

**[Table/Fig-9]:** Kappa statistics in grading of neural foramen stenosis.

or impingement is important in preoperative assessment [8]. Surgical intervention aims at decompressing the compressed and clinically significant nerve roots [9]. These bring the need of a simple, reproducible and acceptable grading system for imaging specialists and clinicians.

We formulated the new grading system by modifying the Grade 3 of Wildermuth system of LNFS. We modified the category of severe neural foramen stenosis by nerve root compression or circumferential effacement of perineural fat. In Wildermuth system, nerve root compression without circumferential obliteration of perineural fat, is underestimated to Grade 2 (moderate stenosis), instead of Grade 3 (severe stenosis). Lee system of LNFS is complex in conceptualisation, for radiologist and clinician. In the new system, even one sided and three sided obliterations of perineural fat comes under grade of moderate stenosis. The practice of new grading system obviates the need of separate reporting of neural foramen stenosis and existing nerve root impingment.

Lateral recess or neural foramen stenosis or extra foraminal nerve compression cause radiculopathy, without localising features for exact site of compression [12,13]. Only imaging can precisely localise these sites of stenosis. Even though maximum nerve root compression occurs in the extended position [14-16] of spine, standard protocol LS MRI is taken in supine neutral position.

The new grading system for LNFS showed substantial to almost perfect interobserver and intraobserver agreement (mean κ value 0.947 and 0.836 respectively). Park HJ et al., obtained an interobserver agreement κ = 0.767 for Lee system and κ = 0.734 for Wildermuth system [10]. We evaluated these two old MRI grading systems earlier and obtained inter and intra observer agreements (κ) 0.700 and 0.762 respectively for Wildermuth system and 0.394 and 0.702 respectively for Lee system [11]. Clinical correlation of the grading system is not possible as central canal, lateral recess and neural foramen stenosis and extraforaminal nerve compression can cause similar clinical features [12,13]. Only imaging can precisely localise these pathologies. All patients imaged only in supine neutral position by the standard protocol, even though maximum nerve root compression occurs in the extended position [14-16].

## LIMITATION

We could not include clinical correlation for the grading system, as stenosis of neural foramen or lateral recess, or extra foraminal nerve compression can cause similar clinical features. Even though postural variations affect the nerve root compression, LS MRI in our study was acquired in a single, supine neutral position. It is difficult to perform several MR scans on patients in different positions, due to lack of compliance and cost. Finally, we did not include direct comparison with previous grading systems.

## CONCLUSION

New grading system is simple and easily reproducible for radiologic reporting. It showed substantial to perfect observer agreement. It can convey clear concept to the clinicians in unambiguous words.

## ACKNOWLEDGMENTS

We express our sincere thanks to Mr. Vidhu M Joshy and Mrs. Jeena M P, Biostatisticians, Department of Community Medicine, Amala Institute of Medical Sciences for statistical analysis.

## REFERENCES

[1] Lee S, Lee JW, Yeom JS, Kim KJ, Kim HJ, Chung SK, et al. A practical MRI grading system for lumbar foraminal stenosis. AJR Am J Roentgenol. 2010;194:1095-98.
[2] Hasegawa T, An HS, Haughton VM, Nowicki BH. Lumbar foraminal stenosis: critical heights of the intervertebral discs and foramina: a cryomicrotome study in cadavera. J Bone Joint Surg Am. 1995;77:32-33.
[3] Grenier N, Kressel HY, Schiebler ML, Grossman RI, Dalinka MK. Normal and degenerative posterior spinal structures: MR imaging. Radiology. 1987;165(2):517-25.
[4] Kunogi J, Hasue M. Diagnosis and operative treatment of intraforaminal and extraforaminal nerve root compression. Spine. 1991;16:1312-20.
[5] Wildermuth S, Zanetti M, Duewell S, Schmid MR, Romanowski B, Benini A, et al. Lumbar spine: Quantitative and qualitative assessment of positional (upright flexion and extension) MR imaging and myelography. Radiology. 1998;207:391-98.
[6] McHugh ML. Interrater reliability: the kappa statistic. Biochem Med (Zagreb). 2012;22(3):276-82.
[7] Landis JR, Koch GG. The measurement of observer agreement for categorical data. Biometrics. 1977;33:159-74.
[8] Carrino JA, Lurie JD, Tosteson AN, Tosteson TD, Carragee EJ, Kaiser J, et al. Lumbar spine: reliability of MR imaging findings. Radiology. 2009;250(1):161-70.

[9] Pfirrmann CW, Dora C, Schmid MR, Zanetti M, Hodler J, Boos N. MR image-based grading of lumbar nerve root compromise due to disk herniation: reliability study with surgical correlation. Radiology. 2004;230(2):583-88.
[10] Park HJ, Kim SS, Lee SY, Park NH, Rho MH, Hong HP, et al. Clinical correlation of a new MR imaging method for assessing lumbar foraminal stenosis. Am J Neuroradiol. 2012;33:818-22.
[11] Varghese B, Babu AC. An analysis on reliability of the lee and wildermuth magnetic resonance imaging grading systems for lumbar neural foraminal stenosis. West African Journal of Radiology. 2017;24:8-13.
[12] Hasegawa T, Mikawa Y, Watanabe R, An HS. Morphometric analysis of the lumbosacral nerve roots and dorsal root ganglia by magnetic resonance imaging. Spine. 1996;21:1005-09.
[13] Attias N, Hayman A, Hipp JA, Noble P, Esses SI. Assessment of MRI in the diagnosis of lumbar spine foraminal stenosis: a surgeon's perspective. J Spinal Disord Tech. 2006;19(4):249-56.
[14] Inufusa A, An H, Lim T, Hasegawa T, Haughton V, Nowicki B. Anatomic changes of the spinal canal and intervertebral foramen associated with flexion–extension movement. Spine. 1996;21:2412-20.
[15] Jenis LG, An HS. Spine update; lumbar foraminal stenosis. Spine. 2000;25:389-94.
[16] Mayoux-Benhamou MA, Revel M, Aaron C, Chomette G, Amor B. A morphological study of the lumbar foramen: influence of flexion-extension movements and of isolated disc collapse. Surg Radiol Anat. 1989;11:97-102.

**AUTHOR(S):**
1. Dr. Binoj Varghese V
2. Dr. Arun C Babu

**PARTICULARS OF CONTRIBUTORS:**
1. Associate Professor, Department of Radiodiagnosis, Amala Institute of Medical Sciences, Thrissur, Kerala, India.
2. Resident, Department of Radiodiagnosis, Amala Institute of Medical Sciences, Thrissur, Kerala, India.

**NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:**
Dr. Binoj Varghese V,
Department of Radiodiagnosis, Amala Institute of Medical Sciences, Amala Nagar, Thrissur-680055, Kerala, India.
E-mail: drbinojv@yahoo.co.uk

**FINANCIAL OR OTHER COMPETING INTERESTS:** None.

Date of Publishing: **Jan 01, 2018**