An Analysis on Reliability of the Lee and Wildermuth Magnetic Resonance Imaging Grading Systems for Lumbar Neural Foraminal Stenosis

Binoj Varghese, Arun C Babu

Department of Radiodiagnosis, Amala Institute of Medical Sciences, Thrissur, Kerala, India

Correspondence: Dr. Binoj Varghese, Department of Radiodiagnosis, Amala Institute of Medical Sciences, Thrissur - 680 055, Kerala, India. E-mail: drbinojv@yahoo.co.uk

ABSTRACT

Background: There is no uniformly accepted magnetic resonance imaging (MRI) grading system existing for lumbar neural foraminal stenosis (LNFS). Radiologists' reporting on neural foramen stenosis is qualitative and subjective. There are two grading systems proposed by Lee and Wildermuth. **Aims:** To evaluate the reliability between Lee and Wildermuth grading systems for lumbar foraminal stenosis and analyze their relative merits. **Settings and Design:** A retrospective, cross-sectional analytical study. **Materials and Methods:** A total of 136 consecutive patients (63 males and 73 females; mean age 56.3 years) aged above 40 years with low backache found to have degenerative disc disease after MRI of the lumbar spine at a tertiary care hospital in South India from July to September 2015. Two general radiologists reviewed the MRI studies independently for the presence and grading of stenosis at L3/4, L4/5, and L5/S1 neural foramina. They graded neural foramen stenosis with Lee and Wildermuth systems at different occasions and were blinded to all previous grading. **Statistical Analysis Used:** Interobserver agreement between the radiologists and intraobserver agreement by one radiologist for one system each were analyzed using kappa statistics. **Results:** Wildermuth system of LNFS showed substantially higher inter- and intra-observer agreements than Lee system. Overall inter-rater and intra-rater agreements (κ) for Wildermuth system are 0.700 and 0.762, respectively, and that of Lee system are 0.394 and 0.702. **Conclusions:** Wildermuth system is more reliable than Lee system for general radiologists. It also accounts slight neural foramen stenosis without perineural fat obliteration unlike in Lee system.

Key words: Foramen; foraminal stenosis; Lee system; lumbar vertebrae; Wildermuth system

Introduction

Lumbar foraminal stenosis is referred to the narrowing of the intervertebral foramen, where the nerve leaves the spinal canal. The etiology is multifactorial involving pathologies of the disc, ligamentum flavum, and facet joints. The incidence of lumbar foraminal stenosis estimated using sagittal magnetic resonance imaging (MRI) is about 48% in a symptomatic group of average age 70 years.[1] Even though MRI is universally used in the evaluation of suspected degenerative disease of the spine, there is no widely used MRI grading system for lumbar neural foraminal stenosis (LNFS). Many radiologists qualify neural foramen stenosis in the MRI reports based on subjective criteria. There are two systems for grading of LNFS. They were proposed by Lee *et al*.[1] on the one hand and Wildermuth *et al*.[2] on the other hand. The Lee *et al*.[1] system is based on the extent of fat obliteration around the exiting nerve root and the nerve root compression. The Wildermuth *et al*. system[2] is based on the extent of foraminal

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and perineural fat obliteration, without considering the nerve root compression. The purpose of our study is to evaluate the reliability of these two grading systems and analyze their relative merits. There is a need for a widely accepted, simple, and reproducible grading system in radiological reporting for better understanding of reports and preoperative planning of foraminotomy.

Materials and Methods

The study was designed as a retrospective, cross-sectional analytical study and was carried out in a tertiary care hospital. Institutional Review Board approved the project protocol. There was no requirement for informed patient consent. We retrieved the imaging and basic demographic data from the picture archiving and communication system.

Case selection

Inclusion criteria: Patients aged 40 years and above who undergone standard protocol Lumbar Spine MRI and diagnosed to have lumbar degenerative disc disease from July 2015 to September 2015 were included in the study. Exclusion criteria: Patients with spinal infections, acute spinal trauma, or spinal malignancy in MRI, and who had previous lumbar spine surgery were excluded from the study. We selected 232 consecutive patients based on the inclusion criteria from the database and excluded 96 patients based on exclusion criteria. Our study population (n = 136) was constituted by 63 males (46.3%) and 73 females (53.7%) with the low back pain and had a mean age of 56.35 years.

Magnetic resonance imaging technique

MRI examinations were performed on a 1.5-T scanner (GE Signa HDxt, GE healthcare, United States) in the supine position. The standard lumbar spine protocol employed in the hospital comprised T1- and T2-weighted images (WIs) in the axial and sagittal plane and short tau inversion recovery images in the coronal plane. We reviewed primarily the sagittal T1-WI and T2-WI for grading. The standard for sagittal images was average of 15 slices, slice thickness of 4 mm with interslice gap of 0.5 mm, and field of view of 30–32 cm. MRI parameters used are given in Table 1.

Table 1: MRI parameters

Sequences	T1-weighted FSE[1] sagittal	T2-weighted FRFSE[2] sagittal
Matrix	512×256	512×288
TR[3] range/Effective TE[4] range (TR/TE)	520-740/14-15	3840-4920/110-120
Echo Train Length (ETL)	5	29
Number of Excitations	4	4

SE[1] – Fast Spin Echo; FRFSE[2] – Fast Recovery Fast Spin Echo; TR[3] – Repetition Time; TE[4] – Echo time

Methodology and grading of neural foraminal stenosis

As we were new to these grading systems of neural foramen stenosis, initially, we conducted a pilot study using Lee system and Wildermuth system. We organized two meetings in our department to attain good understanding and consensus on different grades of these systems. A total of 816 neural foramina (136 × 6) at L3/4, L4/5, and L5/S1 were evaluated. Two general radiologists reviewed the MRI studies independently for grading of NFS, blinded to all previous grading. They graded neural foramen stenosis with both Lee system and Wildermuth system at different occasions. Radiologist 1 regraded the neural foramen stenosis using Lee system, and Radiologist 2 regraded using Wildermuth system after 1 month. We recorded these grades and demographic data of each patient in a predesigned pro forma.

Lee grading system for lumbar neural foraminal stenosis

Grade 0 denotes the absence of foramen stenosis, i.e., without perineural fat obliteration in any two opposing directions. Obliteration refers to complete effacement of perineural fat and contact of the borders of neural foramen, with corresponding side of the nerve root [Figure 1].

Grade 1 denotes mild foraminal stenosis showing perineural fat obliteration in any two opposing directions, vertical or transverse [Figure 2].

Grade 2 denotes moderate foraminal stenosis showing obliteration of perineural fat in the four directions (vertical and transverse directions) without nerve root distortion or collapse [Figure 3].

Grade 3 denotes severe foraminal stenosis showing nerve root collapse or distortion [Figures 4 and 5].[1]

Figure 1: Case of Grade 0 neural foramen, Lee system. T1-weighted sagittal image of a 47-year-old man shows the left L3–4 neural foramen (arrow). Note the normal dimensions of neural foramen and perineural fat. This neural foramen also qualifies for Wildermuth system Grade 0

Figure 2: Case of Grade 1 neural foraminal stenosis, Lee system. T1-weighted sagittal image of a 48-year-old woman with low back pain shows vertical stenosis of left L3-4 neural foramen (arrow) due to the annular bulge. In addition, note the ligamentum flavum hypertrophy and facet joint arthropathy obliterates the posterior perineural fat, but the anterior perineural fat is preserved. This neural foramen qualifies for Wildermuth Grade 2 neural foramen stenosis

Figure 3: Case of Grade 2 neural foraminal stenosis, Lee system. T1-weighted sagittal image of a 65-year-old woman shows vertical and transverse stenosis of the left L5-S1 neural foramen (arrow) due to annular bulge. Note the circumferential obliteration of the perineural fat. This neural foramen also qualifies for Wildermuth Grade 3 neural foramen stenosis

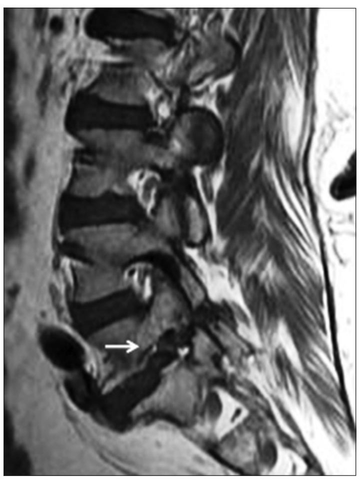

Figure 4: Case of Grade 3 neural foraminal stenosis, Lee system. T1-weighted sagittal image of the 48-year-old woman shows vertical stenosis of left L5-S1 neural foramen with nerve root compression (arrow) due to annular bulge. In addition, note the ligamentum flavum thickening and partially preserved inferior perineural fat. This neural foramen also qualifies for Wildermuth Grade 2 neural foramen stenosis.

Figure 5: Case of Grade 3 neural foraminal stenosis, Lee system. T1-weighted sagittal image of a 58 year-old woman shows circumferential stenosis of right L4–5 neural foramen with nerve root compression (arrow) due to spondylolisthesis, ligamentum flavum thickening, and annular bulge. This neural foramen also qualifies for Wildermuth Grade 3 neural foramen stenosis

Wildermuth grading system for lumbar neural foraminal stenosis

Grade 0 refers to neural foramen without pathology (normal dorsolateral border of the intervertebral disc, near normal height of intervertebral disc, no ligamentum flavum hypertrophy, and normal form of the foraminal epidural fat) [Figure 6].[2]

Grade 1 refers to slight foraminal stenosis with deformity of the epidural fat and the remaining fat still completely surrounding the exiting nerve root [Figure 7].

Grade 2 refers to marked foraminal stenosis with epidural fat only partially surrounding the nerve root [Figure 8].

Grade 3 refers to advanced foraminal stenosis with obliteration of the epidural fat [Figure 9].

Statistical analysis

The data obtained were entered into the excel spreadsheet and analyzed using Statistical Package for the Social Sciences for Windows (SPSS for windows, Version 16.0. Chicago, SPSS Inc.). Interobserver agreement between the two radiologists and intraobserver agreement of one radiologist for these two grading systems were analyzed using kappa statistics. The levels of agreement between observers for the kappa values are ≤0.20, 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 between observers.[3]

Figure 6: Case of Grade 0 neural foramen, Wildermuth system. T1-weighted sagittal image of a 57-year-old man shows the right L3–4 neural foramen (arrow), with normal form of the foraminal epidural fat. This neural foramen also qualifies for Grade 0, Lee system

Figure 7: Case of Grade 1 neural foramen stenosis, Wildermuth system. T1-weighted sagittal image of a 70-year-old man shows the right L3–4 neural foramen (arrow), with distorted foraminal epidural fat due to posterolateral annular bulge. Hence, perineural fat is preserved. This neural foramen also qualifies for Grade 0, Lee system

Figure 8: Case of Grade 2 neural foramen stenosis, Wildermuth system. T1-weighted sagittal image of the 70-year-old man shows the right L4–5 neural foramen (arrow) with partially obliterated perineural fat. Note the superior vertebral body endplate osteophyte with annular bulge and ligamentum flavum thickening. This neural foramen also qualifies for Grade 1, Lee system

Figure 9: Case of Grade 3 neural foramen stenosis, Wildermuth system. T1-weighted sagittal image of the 58-year-old woman shows the right L4–5 neural foramen (arrow) with obliteration of perineural fat. This neural foramen also qualifies for Grade 3, Lee system

Results

The frequency of LNFS by observers using the Lee and Wildermuth systems is given in Tables 2 and 3. Inter- and intra-observer agreements (kappa statistics κ) for each neural foramen using these two systems are given in Tables 4 and 5. Overall inter- and intra-rater agreements (κ) for Wildermuth system are 0.700 and 0.762, respectively, and for Lee system are 0.394 and 0.702. Inter- and intra-observer agreements for the Wildermuth system are higher than Lee system. The frequency of foraminal stenosis is more at lower levels (L5-S1 and L4-5) than at higher level (L3-4).

Discussion

Neural foramina are lateral exit zones of the spinal nerve roots from the spinal canal. The anterior boundaries are posteroinferior margin of the superior vertebral body, posterolateral margin of the intervertebral disc, and posterosuperior margin of the inferior vertebral body. The posterior boundaries are ligamentum flavum and superior articular process. The pedicles form superior and inferior margins. Neural foramen stenosis has a multifactorial etiology. The factors are hypertrophic ligamentum flavum, osteophytes from vertebral margins, disc space narrowing, laterally bulging annulus or herniated disc, spondylolisthesis, and facet joint hypertrophy. These changes can cause circumferential or focal narrowing of neural foramen, obliteration of perineural fat, or nerve root compression. The lumbar nerve roots pass through the lateral recess after originating from the thecal sac and before passing through the neural foramen. In the foramen, the exiting nerve root and dorsal root ganglion are commonly located in the superior and anterior regions. These neural structures are surrounded by fat and radicular vessels and approximately occupy 30% of the available foraminal area.[4] Dorsal nerve root ganglion can be also seen intraspinally.

We observed that Wildermuth system of LNFS is simple and considers mild neural foramen stenosis, without obliteration of perineural epidural fat. However, it can underestimate the degree of NFS as it is not considering the nerve root compression. If nerve root compression occurs without circumferential obliteration of perineural fat, this system categorizes to Grade 2 (moderate stenosis) instead of Grade 3 (severe stenosis) [Figure 4]. Lee system of LNFS requires more effort in understanding the concept. It qualifies for NFS only if there is obliteration of perineural fat in at least two opposing directions. Hence, reduction in neural foramen volume alone is not considered as NFS but included in the Grade 0 category. Because of the differences in the criteria, similar grades of the two systems are not comparable. The other drawback of Lee grading system is perineural fat obliteration at adjacent margins (nonopposing margins) or one side is not included as neural foramen stenosis.

Table 2: Frequency of Lumbar neural foraminal stenosis using Lee system

Observer	Neural foramina	Grade 0	Grade 1	Grade 2	Grade 3
Radiologist 1	L3/4	245	23	2	2
	L4/5	210	53	3	6
	L5/S1	230	22	5	15
Radiologist 2	L3/4	225	43	2	2
	L4/5	166	85	8	13
	L5/S1	192	49	6	25
Regrading by Radiologist 1after 1 month	L3/4	246	22	2	2
	L4/5	222	39	5	6
	L5/S1	231	24	5	12

Table 3: Frequency of Lumbar neural foraminal stenosis using Wildermuth system

Observer	Neural foramina	Grade 0	Grade 1	Grade 2	Grade 3
Radiologist 1	L3/4	31	147	91	3
	L4/5	9	132	125	6
	L5/S1	95	98	70	9
Radiologist 2	L3/4	31	166	73	2
	L4/5	5	139	123	5
	L5/S1	89	109	67	7
Regrading by Radiologist 2after 1 month	L3/4	31	169	70	2
	L4/5	5	131	131	5
	L5/S1	92	104	69	7

In this study, Wildermuth system for LNFS showed substantially higher agreement (interobserver κ value 0.700 and intraobserver κ value 0.762) than the Lee system (interobserver κ value 0.394 and intraobserver κ value 0.702). However, Park *et al*.[5] reported substantial interobserver agreement (κ value for Lee system, 0.767 and that for Wildermuth system, 0.734) in a symptomatic population of mean age 50.6 years. They also compared these two systems, but according to our concept, the grades of two systems are incomparable. Lee *et al*.[1] in 2009 reported nearly perfect inter- and intra-observer agreements (κ value 0.81–1.0) in a symptomatic population of average age 69.35 years using their grading system. Wildermuth *et al*.[2] in 1998 reported moderate interobserver agreement (k = 0.62) using their grading system. The difference in previous observations of Lee system with our observations may be due to the difference in conceptualization of grading, complexity, and incompatibility with global assessment. Grading using Wildermuth *et al*. system in this study showed correlation with the previous studies.[2,5]

There were a few practical limitations to this study. As the objective was to test the reliability of grading systems, there was no clinical correlation. Moreover, no findings can easily localize significant pathology at the foramen without the aid of imaging.[4] As the patients were imaged only in supine neutral position by the standard protocol, the effect of posture on neural foramen dimensions is not considered in this study. Inufusa *et al*.[6] reported the effects of flexion, extension, and neural position on nerve root compression, using computed

Table 4: Kappa statistics in grading of neural foramen stenosis using Lee system

	Right L3-4	Right L4-5	Right L5-S1	Left L3-4	Left L4-5	Left L5-S1
Radiologist 1 vs Radiologist 2	0.470	0.317	0.356	0.518	0.361	0.347
Intra raterRadiologist1	0.765	0.590	0.733	0.696	0.677	0.754

Table 5: Kappa statistics in grading of neural foramen stenosis using Wildermuth system

	Right L3-4	Right L4-5	Right L5-S1	Left L3-4	Left L4-5	Left L5-S1
Radiologist 1 vs Radiologist 2	0.683	0.759	0.653	0.708	0.781	0.620
Intra raterRadiologist2	0.725	0.702	0.717	0.825	0.805	0.803

tomography scan and cryomicrotome analyses. They showed maximum nerve root compression in the extended position due to increased intervertebral translation, disc bulging, and bulging of hypertrophied ligamentum flavum.

Conclusions

Wildermuth grading system is more reliable than the Lee system for general radiologists. It showed substantially correlated inter- and intra-observer agreements. Wildermuth system is also simple to understand and accounts slight neural foramen stenosis. A significant drawback of this system is noninclusion of nerve root compression in the grading. Nerve root compression and collapse can happen without circumferential obliteration of the perineural fat. Hence, we suggest the inclusion of nerve root compression in the 3rd category of grading system.

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Conflicts of interest

There are no conflicts of interest.

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;194:1095-8.
2. 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;207:391-8.
3. Sim J, Wright CC. The kappa statistic in reliability studies: Use, interpretation, and sample size requirements. Phys Ther 2005;85:257-68.
4. Jenis LG, An HS. Spine update. Lumbar foraminal stenosis. Spine (Phila Pa 1976) 2000;25:389-94.
5. 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. AJNR Am J Neuroradiol 2012;33:818-22.
6. Inufusa A, An HS, Lim TH, Hasegawa T, Haughton VM, Nowicki BH. Anatomic changes of the spinal canal and intervertebral foramen associated with flexion-extension movement. Spine (Phila Pa 1976) 1996;21:2412-20.