

Clinical Study

Utility of repeat magnetic resonance imaging in surgical patients with lumbar stenosis without disc herniation

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Abstract

BACKGROUND CONTEXT: Routine use of magnetic resonance imaging (MRI) as a diagnostic tool in lumbar stenosis is becoming more prevalent due to the aging population. Currently, there is no clinical guideline to clarify the utility of repeat MRI in patients with lumbar stenosis, without instability, neurological deficits, or disc herniation.

PURPOSE: To evaluate the utility of routine use of MRI as a diagnostic tool in lumbar stenosis, and to help formulate clinical guidelines on the appropriate use of preoperative imaging for lumbar stenosis.

STUDY DESIGN/SETTING: Retrospective radiographic analysis.

PATIENT SAMPLE: Retrospective chart review was performed to review patients with lumbar stenosis, who underwent lumbar decompression without fusion from 2011 to 2015 at a single institution.

OUTCOME MEASURES: Previously established stenosis grading systems were used to measure and compare the initial and the subsequent repeat lumbar MRIs performed preoperatively. If patients were found to have a moderate or severe grade change, and if the surgical plan was altered due to such exacerbated radiographic findings, then their grade changes were considered clinically meaningful.

METHODS: We identified patients with lumbar stenosis without radiographic instability or neurological deficits, who had at least two preoperative lumbar MRIs performed and underwent decompressive surgeries. At each pathologic disc level, the absolute value of the change in grade for central and lateral recess stenosis, right foraminal stenosis, and left foraminal stenosis from the first preoperative MRI to the repeated MRI was calculated. These changed data were then used to calculate the mean and median changes in each of the three types of stenosis for each pathologic disc level. Identical calculations were carried out for the subsample of patients who only underwent discectomy or had a discectomy included as part of their surgery.

RESULTS: Among the 103 patients who met the inclusion criteria, 37 of those patients had more than one level surgically addressed, and a total of 161 lumbar levels were reviewed. Among the subset of patients that had any grade change, the majority of the grades only had a mild change of 1 (36 out of 42 patients, 85.7%, 95% confidence interval [CI]: 73.1%–94.1%); there was a moderate grade change of 2 in two patients (4.8%, CI: 0.8%–14.0%), and a severe change of 3 in one patient (2.4%, CI: 0.2%–10.1%). There were three patients with decreased grade change (7.1%, CI:

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1.8%–17.5%). All clinically meaningful grade changes were from the subset of patients who had only discectomy or discectomy as part of the procedure. Lastly, both patients that had a clinically meaningful grade change had their MRIs performed at an interval of greater than 360 days.

CONCLUSIONS: The radiographic evaluation of the utility of routinely repeated MRIs in lumbar stenosis without instability, neurological deficits, or disc herniations demonstrated that there were no significant changes found in the repeated MRI in the preoperative setting, especially if the MRIs were performed less than one year apart. The results of this present study can help to standardize the diagnostic evaluation of lumbar stenosis and to formulate clinical guidelines on the appropriate use of preoperative imaging for lumbar stenosis patients. © 2018 Elsevier Inc. All rights reserved.

Keywords: Diagnostic imaging; Health care expenditure; Lumbar stenosis; Lumbar MRI; Magnetic resonance imaging (MRI); Repeat lumbar MRI; Repeat lumbar MRI utility; Routine lumbar MRI; Routine lumbar MRI utility.

Introduction

Low back pain and radiculopathy secondary to lumbar stenosis in the degenerative lumbar spine are highly prevalent in the adult population [1–5]. Advanced imaging modalities, such as magnetic resonance imaging (MRI) and computed tomography, are increasingly utilized as diagnostic methods in evaluating the etiology of low back pain or radiculopathy [6–8]. Degenerative changes, such as disc herniation, disc height loss, ligamentum hypertrophy, and facet hypertrophy, are common findings in lumbar stenosis and lead to radiculopathy, paresthesia, and neurological deficits [9]. Relative to other imaging modalities, MRI enables direct visualization of soft tissue, which allows for monitoring and screening of progressive disc degeneration and herniation [1, 10]. Therefore, in symptomatic patients with lumbar stenosis that fail conservative management, MRI remains the diagnostic imaging modality of choice because it provides the most accurate information in the initial assessment of degenerative diseases [9].

Despite numerous established guidelines, heterogeneity in the optimal diagnostic imaging work-up protocol and management of back pain in degenerative lumbar spine patients remains [1–6, 9–15]. This heterogeneity is due in part to prior studies that found radiographic evidence of degenerative processes in both symptomatic and asymptomatic patients [15, 16]. As the United States population continues to age and the number of patients presenting to surgeons with low back pain increases, it is increasingly important to identify low-value care in the surgical spine setting [13, 17, 18]. During the present era of increased emphasis on maximizing the cost-effectiveness of care, studying the utility and cost effectiveness of routinely obtained images is warranted.

One example of costly imaging with unknown utility is repeating MRI in the setting of lumbar stenosis secondary to facet and/or ligamentum hypertrophy without disc herniations. Current routine care for surgical candidates with radiographic findings of lumbar stenosis that return with refractory symptoms after conservative management is to obtain a second MRI in search of new findings potentially exacerbating the stenotic effect. However, there are no

clinical guidelines or studies to clarify the utility of repeat MRI as part of the standard preoperative radiographic evaluation. This present study investigated the utility of repeat MRI in patients with lumbar stenosis. We hypothesized that routinely repeated MRIs would not show significant changes in stenosis severity in the setting of symptomatic lumbar stenosis without instability or disc herniations.

Material and methods

Population and data collection

An Institutional Review Board protocol (Institutional Review Board #17-558) was obtained prior to conducting this present study. Study data were collected and managed using Research Electronic Data Capture tools hosted at our institution. The electronic medical record was retrospectively reviewed to identify all patients that underwent lumbar decompression via laminectomy, laminotomy, foraminotomy, and/or discectomy at a single tertiary-care institution from 2011 to 2015. Preoperative and postoperative clinic notes in the electronic medical record were thoroughly reviewed to only include patients with clear documentation to explain any changes in the operative plan. Complete demographic data and presenting symptoms were obtained for those patients that met our inclusion criteria (Table 1).

We included patients that initially presented with symptomatic lumbar stenosis without radiographic instability or clinical neurological deficits, and subsequently underwent surgical decompression after returning with refractory symptoms despite conservative management. Patients who initially presented with neurological deficits, such as weakness, urinary or fecal incontinence, or saddle anesthesia, and those who underwent repeat MRI due to such new findings of neurological deficits were excluded. We also excluded patients with radiographic findings of instability, including spondylolisthesis, spondylolysis, and/or hyperintense T2 facet signals on MRI. Those patients who underwent surgical decompression but did not obtain a repeat MRI prior to surgery, those with MRIs of suboptimal quality of below 1.5T, and those without clear documentation to

Table 1
Patient Characteristics and Demographics.

Demographics	
Number	103
Median age	59 ± 17
Male	58%
Body mass index	30 ± 7
Smoking history	53%
Current smokers	27%
Medications	
Antidepressants	31%
Anxiolytics	25%
Narcotics	30%
NSAIDs	68%
Co-morbidities	
Hypertension	67%
Dyslipidemia	74%
Diabetes	25%
Presenting symptoms	
Axial back pain	68%
Radicular pain	79%
Paresthesias	80%

Mean ± standard deviation for continuous variables, percent for categorical variables.

Percentages in each category combine to greater than 100% as an individual patient may have more than one diagnosis and symptom; NSAID'S = Nonsteroidal anti-inflammatories.

explain any change in the operative procedure, were also excluded. Lastly, as herniated lumbar discs have been demonstrated to undergo spontaneous resolution from the review of serial MRI images, separate analysis was performed for the subsample of patients who only underwent discectomy or had a discectomy included as part of their surgery [19, 20].

Stenosis severity grading methods

Grading systems were adopted and modified from Schizas's grading system for central and lateral recess stenosis, and Lee et al.'s foraminal stenosis grading system [21, 22]. These grading scales were used to measure and compare the severity of stenosis in the initial and the subsequent repeat lumbar MRI performed preoperatively. Schizas et al. described qualitative grading system to assess the severity of lumbar spinal stenosis based on the morphology of the thecal sac on axial MRI sequences [22]. A 7-grade classification of the extent of the thecal sac compression based on the rootlet-cerebrospinal fluid ratio was obtained from T2 axial MRI sequences [22]. In order to simplify the grading system, we modified the Schizas's 7-grade system by collectively classifying the first four grades of A1 to A4 into grade 1. Then grade B was converted to grade 2, grade C to grade 3, and grade D to grade 4 (Fig. 1) [22]. Lee et al.'s grading system for foraminal stenosis was modified to be consistent with the modified Schizas's grades: Grades 0–3 were converted to grades 1–4 [21]. Grade 1 denotes minimal stenosis, grade 2 moderate, grade 3 moderate-to-severe, and grade 4 severe stenosis (Fig. 2). If patients were found

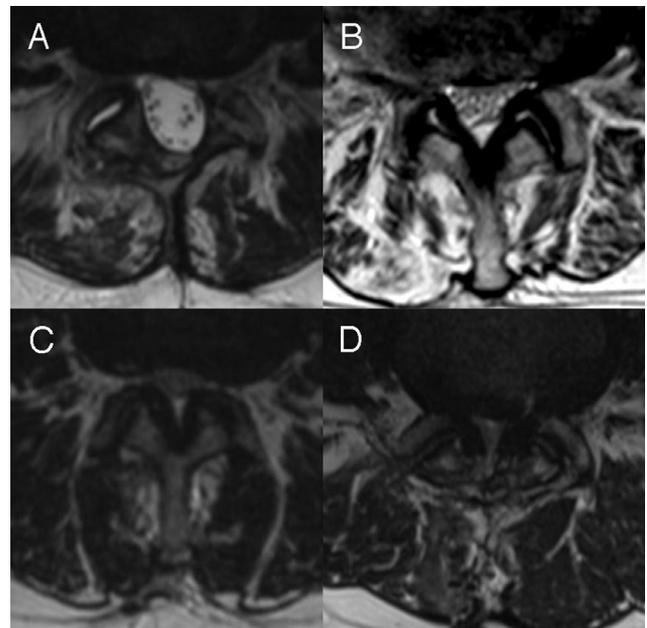


Fig. 1. Modified Schizas's grading system for central and lateral recess stenosis. (A) Grade 1: Clear cerebrospinal fluid is visible in the thecal sac; (B) Grade 2: Rootlets now occupy the entire thecal sac but can still be individualized without severe thecal sac effacement; (C) Grade 3: Rootlets can no longer be visualized, and the thecal sac is completely effaced. The epidural fat is still visible; (D) The thecal sac and epidural fat are no longer visible [22].

to have a moderate or severe grade change of 2 or 3, and if the surgical plan was altered due to such exacerbated radiographic findings, then their grade changes were considered clinically meaningful.

Two neurosurgery residents reviewed all the imaged levels for both the initial and the repeat MRIs. Each level was then reviewed again by neuroradiologists. If the grades differed significantly between reviewers, then a third reviewer (a fellowship-trained spine surgeon) acted as the final arbitrator for the grade. We calculated a Cohen's kappa coefficient to assess inter-rater reliability for the stenosis grades. Cohen's kappa coefficient is specifically designed to account for the possibility that raters agree by chance when using a categorical rating system in Schizas's and Lee et al.'s stenosis grading schemes.

Statistical methods

At each pathologic disc level, the absolute value of the change in grade for central and lateral recess stenosis, right foraminal stenosis, and left foraminal stenosis from the first preoperative MRI to the repeated MRI was calculated. These changed data were then used to calculate the mean change in each of the three types of stenosis for each pathologic disc level. The absolute value of the change in grade for each type of stenosis was used because including both positive (i.e. change of stenosis grade from 2 to 3) and negative (i.e. change of stenosis grade from 3 to 2) changes would have biased our results toward a mean of 0 or no

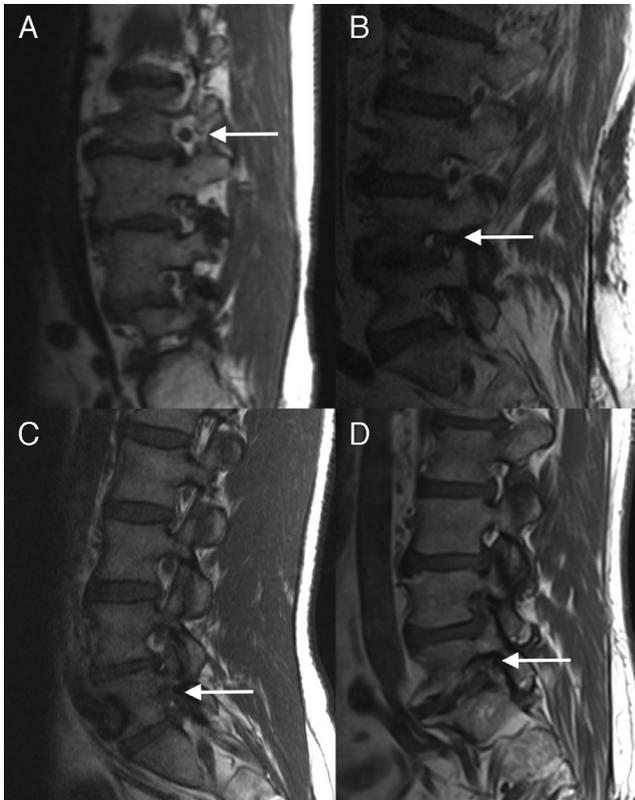


Fig. 2. Modified Lee et al.'s grading system for foraminal stenosis, with arrows indicating the level of described stenosis. (A) Grade 1: Absence of foraminal stenosis; (B) Grade 2: Mild foraminal stenosis in which perineural fat obliteration occurs in either vertical or horizontal direction; (C) Grade 3: Moderate foraminal stenosis in which perineural fat obliteration occurs in both vertical and horizontal directions without the morphologic change of the exiting nerve root; (D) Grade 4: Severe foraminal stenosis in which there is significant compression of the nerve root leading to its morphologic change [21].

change even though a change may have occurred. The goal of this present study was to determine if the severity of stenosis changed at all from the initial to the repeat MRI, not whether patients experienced an improvement or worsening of their stenosis from the initial MRI to the repeat MRI. The median change with interquartile range in the severity of each of the three regions of stenosis was also calculated because of concern that the data were skewed. Next, both the mean and median change in stenosis severity were calculated for the subset of patients that actually experienced a change in severity. This analysis was undertaken to quantify the extent of change in stenosis severity that could be expected if a patient's stenosis changed at all. Finally, identical calculations were carried out for the subsample of patients who only underwent discectomy or had a discectomy included as part of their surgery. Confidence intervals were constructed using the profile likelihood method.

Results

Among the 3,297 patients that underwent lumbar decompressive operations for symptomatic lumbar stenosis, we identified a total of 103 patients that met all our

inclusion criteria as described above, and their complete demographic data are shown in Table 1. A total of 37 patients had more than one level surgically addressed, and a total of 161 lumbar levels were reviewed for comparison of the extent of stenosis between two preoperative MRIs.

A total of 40.8% (95% CI: 31.6%–50.4%) of all patients (42 out of 103) had at least one change in the grades for central and lateral recess, right foraminal, or left foraminal stenosis across all levels, and 26.1% (CI: 19.7%–33.2%) of all levels had at least one change in any one of the grades (42 out of 161) (Table 2). However, among the subset of patients that had any grade change, the majority of the grades only had a mild change of 1 (36 out of 42 patients, 85.7%, CI: 73.1%–94.1%; 36 out of 42 levels, 85.7%, CI: 73.1%–94.1%); there was a moderate grade change of 2 in two patients (4.8%, CI: 0.8%–14.0%), and a severe change of 3 in one patient (2.4%, CI: 0.2%–10.1%). There were three patients with decreased grade change (7.1%, CI: 1.8%–17.5%). Surgical plan was not altered in any of the patients with no grade change or a mild grade change of 1. All clinically meaningful grade changes were from the subset of patients who had only discectomy or discectomy as part of the procedure (Table 2). A total of 4.9% (CI: 1.8%–10.1%) of patients (5 out of 103) had both central and lateral recess stenosis and foraminal stenosis grade changes.

Among all patients, the median difference between the first and second MRI in the grades for central and lateral recess, right foraminal, and left foraminal stenosis were all zero. The mean changes in those same measurements were 0.12, 0.11, and 0.14, respectively. Among the subset of levels that were found to have a change in stenosis severity, the median change was 1 for each stenosis location, and the mean change was 1.19, 1.0, and 1.05 for central and lateral recess, right foraminal, and left foraminal stenosis, respectively. When the subset of patients who underwent discectomy or decompression with discectomy was excluded, the median change remained 1 for each stenosis location, and the mean change was 1.0, 1.0, and 1.17 for central and lateral recess, right foraminal, and left foraminal stenosis, respectively (Table 2).

The mean and median number of days elapsed between the first and the repeat preoperative MRI in all patients were 572 and 459 days, respectively (range 11–2,044 days), and the mean and median number of days elapsed between the repeated preoperative MRI and the surgery in all patients were 77 and 51 days, respectively (range 1–343 days). Among the patients that had any grade change, 4.9% (CI: 0.8%–14.0%) of patients (2 out of 42) had the two MRIs performed at an interval of fewer than 30 days; no patients' MRIs had an interval between 31 and 90 days; 4.9% (CI: 0.8%–14.0%) of patients' MRIs (2 out of 42) had an interval between 91 and 180 days; 36.6% (CI: 22.4%–50.7%) of patients' MRIs (15 out of 42) had an interval between 181 and 360 days; and 53.7% (CI: 37.5%–67.0%) of patients' MRIs (22 out of 42) had an

Table 2
Stenosis Severity Grade Changes.

	All patients (103) 42 (40.8%)			Disc patients (39) 26 (66.7%)			Nondisc patients (64) 16 (25.0%)		
	CL	RF	LF	CL	RF	LF	CL	RF	LF
Patients with at least one changed grade									
Patients with changed grade	16 (15.5%)	17 (16.5%)	22 (21.4%)	10 (25.6%)	11 (28.2%)	17 (43.6%)	6 (9.4%)	6 (9.4%)	5 (7.8%)
Mean change (in all patients)	0.12	0.11	0.14	0.33	0.28	0.41	0.05	0.05	0.06
Mean change (if a change occurred)	1.19	1	1.05	1.3	1	1	1	1	1.17
	All patients with changed grade (42)			Disc patients with changed grade (26)			Nondisc patients with changed grade (16)		
Patients with decreased grade change	3 (7.1%)			1 (3.8%)			2 (12.5%)		
Patients with mild grade change	36 (85.7%)			23 (88.5%)			13 (81.2%)		
Patients with moderate-severe change	3 (7.1%)			2 (7.7%)			1 (6.2%)		
Patients with clinically meaningful change	2 (4.8%)			2 (7.7%)			0		

CL = Central and lateral recess stenosis; RF = Right foraminal stenosis; LF = Left foraminal stenosis.

interval greater than 360 days. Among the three patients who had a grade change of 2 or 3, two patients had greater than 360 elapsed days between the two MRIs, and one patient’s MRIs were performed at an interval between 91 and 180 days. Both patients that had a clinically meaningful grade change had their MRIs performed at an interval of greater than 360 days (Table 3).

The Cohen’s kappa coefficients between the two raters’ grades were 0.92, 0.85, and 0.80 for central and lateral recess stenosis, right foraminal stenosis, and left foraminal stenosis, respectively. As stated previously, when there was disagreement between the raters, a third reviewer acted as the final arbitrator.

Discussion

As health care costs continue to rise (estimates suggest health care will account for 20% of the gross domestic product of the United States by 2020) [13, 17, 23], increased emphasis is being placed on identifying potentially avoidable interventions [24–26]. In 2010, approximately \$765 billion in health care expenditures were categorized as unnecessary and of this amount, \$210 billion was attributed to unnecessary services ordered by physicians and clinicians [23, 26]. In the present era of exponentially increasing health care expenditures, health care providers are expected to be more cost-conscious and judicious with the utilization of finite health care resources.

Table 3
Time Intervals Between Two Preoperative MRIs.

Elapsed days between MRIs	Nondisectomy patients					
	Changes in central and lateral recess stenosis grade			Changes in right or left foraminal stenosis grade		
	-1	1	2 or 3	-1	1	2 or 3
0–30 d	0	0	0	0	0	0
31–90 d	0	0	0	0	0	0
91–180 d	0	0	0	0	0	0
181–360 d	1	4	0	0	1	0
>360 d	0	1	0	1	7	1
Elapsed days between MRIs	Discectomy patients					
	Changes in central and lateral recess stenosis grade			Changes in right or left foraminal stenosis grade		
	-1	1	2 or 3	-1	1	2 or 3
0–30 d	0	0	0	0	2	0
31–90 d	0	0	0	0	0	0
91–180 d	0	0	1	0	2	0
181–360 d	1	2	0	1	7	0
>360 d	0	5	1	0	9	0

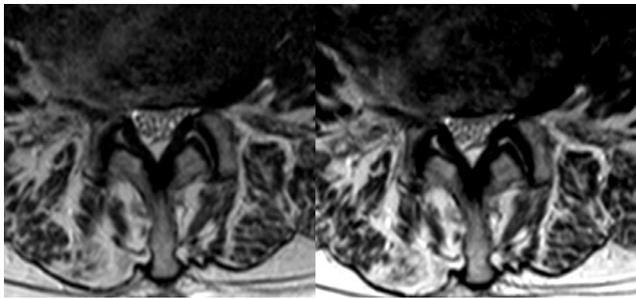


Fig. 3. Magnetic resonance imaging T2-weighted axial sequences without contrast demonstrating similar severity of central and lateral recess stenosis at L3-4 between two preoperative MRIs in a patient that underwent laminectomy for decompression. There was elapsed time of 329 days between (Left) the first and (Right) the repeat MRI.

However, prior studies demonstrated that most physicians have limited knowledge and understanding of the costs of health care services [27–29]. In survey studies that investigated knowledge about health care costs among postgraduate physicians and training physicians across a variety of specialties, physicians had very limited awareness of the costs of commonly ordered imaging modalities, including MRI [30, 31].

Although the use of routine diagnostic imaging has rapidly increased among patients with low back pain over the last two decades, the value of repeating MRI for lumbar stenosis remains unknown. In the present radiographic study of the severity of lumbar stenosis, none of the patients that underwent routine lumbar decompressive operations due to central and lateral recess or foraminal stenosis from ligamentum hypertrophy, facet hypertrophy, or decreased disc height without herniated or extruded disc fragments presented with clinically meaningful changes in stenosis severity from their index to their second preoperative MRI (Figs. 3 and 4).

The presence of large disc extrusion with resultant compression of a nerve root leading to persistent radiculopathy refractory to medical management, neurological deficits, or urgent findings such as cauda equina syndrome, is considered an indication for prompt surgical treatment [32]. However, herniated lumbar discs have been observed to have spontaneous resolution from the review of serial MRI images, and it has been demonstrated that the amount of reduction in the size of the herniated disc fragment over time has a direct correlation with the extent of degenerative changes and the size of the herniated disc material [19, 20]. In a prospective study, Takada et al. sequentially reviewed MRIs to investigate the morphologic changes and sizes of lumbar disc herniation in 42 patients. Takada et al. found that 88% of the 42 patients showed >50% reduction of the herniated fragment on MRI 3 to 12 months after the initial onset of symptoms, and such morphologic changes correlated well with the clinical findings and outcomes [20]. Due to the unpredictable natural history of the herniated or extruded disc fragment, in the absence of urgent

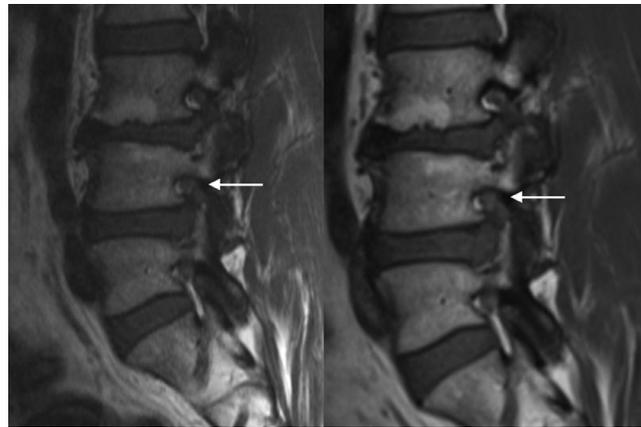


Fig. 4. Magnetic resonance imaging T1-weighted sagittal sequences without contrast demonstrating similar severity of right foraminal stenosis at L4-5 between two preoperative MRIs in a patient that underwent right L4-5 laminotomy and foraminotomy for decompression. There was elapsed time of 379 days between (Left) the first and (Right) the repeat MRI.

neurological deficits or instability, surgeons initially resort to conservative management for symptomatic control and offer surgical treatment only when symptoms remain refractory to medical treatments. When conservative management fails to provide symptom relief and patients return for a follow up visit, MRI imaging is often repeated, as the extruded disc fragment may have resolved spontaneously.

The results of this present study provide further evidence that the use of routine imaging should be evaluated through the lens of relative efficacy. We found that only 2.9% of all patients (3 out of 103) were found to have a moderate-to-severe grade change of 2 or 3. Only 1.9% (2 out of 103) had a clinically meaningful change of 2 or 3 in the severity of their stenosis that altered surgical planning, and both of these patients were in the discectomy subset. Among the subset of patients who underwent lumbar decompression without discectomy, there were no clinically meaningful grade changes. The patients with a clinically meaningful grade change had their MRIs performed in the interval of greater than 360 days. These findings suggest that repeat MRI for lumbar stenosis without disc herniation may be of very low value unless patients present with new neurological deficits, especially if the repeat MRI is performed within a year from the previous MRI.

Our analysis was limited by the retrospective study design and a relatively small sample size. Moreover, we did not test for differences between the patients who did not meet the inclusion criteria and those that were included due to the absence of a repeat MRI performed. However, among all the patients that met our inclusion criteria, patients were properly substratified for more clinically relevant subset analysis. Also, the grading systems utilized in our study resort to direct surface measurement, which can be a limitation in analyzing the three-dimensional anatomy of the spine. Lastly, even though the clinical meaningful change in severity grades was delineated and reviewed, any

potential differences in clinical outcomes associated with repeating the MRI were not reviewed. Additional prospective studies with a larger sample size investigating the correlation with clinical outcome changes are warranted to further analyze the validity of routinely repeated MRIs in the preoperative setting for lumbar stenosis without disc herniation or instability.

Conclusions

In this present study, 25% (CI: 15.5%–36.5%) of repeat MRIs among patients without disc herniation that underwent lumbar decompressive surgery showed changes in severity grade from the index MRI. However, no patient in this subset had a clinically meaningful stenosis grade change. Such findings suggest that repeat MRI for lumbar stenosis without disc herniation may be of very low value unless patients present with new neurological deficits, especially if repeat MRI is performed within a year from the previous MRI. The results of this present study can help to standardize the diagnostic evaluation of lumbar stenosis and to formulate clinical guidelines on the appropriate use of preoperative imaging for lumbar stenosis patients.

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