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Diagnostic Accuracy of Limited Protocol MRI for Diagnosis of Lumbar Disc Degeneration

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ABSTRACT

OBJECTIVE: To determine the accuracy of limited protocol Magnetic resonance imaging of lumbar spine in determination of lumbar disc herniation, nerve root compression and annular tear taking findings of routine MRI as a reference standard.

METHODOLOGY: A descriptive cross-sectional study was conducted from August 2016 to February 2017 at Dow Institute of Radiology (DIR), Dow University of Health Sciences (DUHS). All patients of either gender aged 20 years or more presenting for MRI with low back pain were included. Routine complete protocol included T1W spin echo (SE) images on the sagittal plane, fat suppression sequence on the sagittal plane and T2W fast spin echo (FSE) images on the sagittal and axial planes, while limited protocol included T2W fast spin echo images on the sagittal and axial planes.

RESULTS: The sensitivity and specificity of limited protocol of disc herniation, nerve root compression, and AT were found to be 100% taking full protocol for disc herniation, nerve root compression, and AT as a gold standard. A significant difference of disc herniation was observed with age (p-value: <0.001), gender (p-value: 0.011), NRC (p-value: <0.001), and AT (p-value: <0.001).

CONCLUSION: Limited protocol MRI of lumbar spine can lead to a definite diagnosis of LDH, NRC and AT without causing any loss of information.

KEYWORDS: Low back pain, diagnostic accuracy, limited protocol MRI, disc herniation, nerve root compression

INTRODUCTION

Pain in the lower back with or without sciatica is a common problem in the world due to degenerative disease of spine[1-3]. The reported frequency ranges from 60-85 percent[4-6] and is a major cause of disability and morbidity in population. Mild degenerative changes are normally present in an aging spine. However, they should be considered pathological if they are causing clinical signs and symptoms. Degenerative disc disease (DDD) of lumbar spine commonly occurs in the form of lumbar disc herniation (LDH) with or without NRC or spinal canal stenosis. A study from our population reported that prevalence of disc herniation is 66.9% as a cause of disc degeneration[7]. Annular tear (AT), which is gap in the fibers of annulus fibrosus, may occur in DDD or in setting of acute trauma.

For initial evaluation of lumbar spine, X-ray is commonly prescribed to look for any gross bony abnormality. However, most of the times the abnormality is related to soft tissues such as intervertebral discs, ligaments, spinal cord and exiting nerve roots. Plain X-ray fails to diagnose these abnormalities. With high spatial resolution, imaging in multiple planes and accurate details MRI has become a preferred modality for initial investigation of lower backache. A study has reported diagnostic accuracy of full-protocol MRI as sensitivity 82.6%, specificity 82.6%, and 70.8% in diagnosis of LDH, and of 80.6% and 100% respectively in diagnosis of NRC[8].

There are certain drawbacks of full protocol MRI such as limited availability, increased time to preform and high cost. An alternative investigation that delivers acceptable results by utilizing less time and cost is required[9]. Limited MR lumbar spine protocol can also be termed as a screening study and utilizes T2 weighted axial and sagittal sequences. The limited protocol MRI can be performed rapidly and reduces the study cost by approximately more than 50%[10]. The sensitivity and specificity of limited MRI protocol for LDH is approximately 82.6% and 80% respectively and for radiculopathy is 54.8% and 100% respectively[8].

Pakistan is a developing country with significant disease burden in a population which can not afford quality care. In a developing country like Pakistan, accurate imaging is required to provide cost-effective and evidence-based treatment. There are very few studies to test the use of a specific lumbar spine treatment in the diagnosis of lumbar disk degeneration. Therefore, the aim of the current study was to determine the accuracy of limited protocol MRI of the lumbar spine in diagnosis of LDH, NRC and AT taking findings of routine MRI as a reference standard. Moreover, another objective was to determine the association of LDH with age, gender, NRC and AT.

METHODOLOGY

A prospective study of MRI scans was performed from August 28th 2016 till February 28th 2017 for six months. Both male and female patients aged 20-60 years or more presenting for MRI with low back pain for duration of one or more months were included. Patients having a history of spinal surgery or those diagnosed with LDH, NRC and AT and presenting for follow up were excluded. Taking sensitivity 82.6%, specificity 80%, prevalence 66.9%, confidence interval 95% and absolute precision 10% the sample size came out to be 131 but a larger sample size of 916 was collected.

LDH on MRI was characterized by diffuse disk bulge, disc protrusion, or sequestration. The diffuse disk bulge was described as a diffusely bulging disk which extends symmetrically beyond the margins of adjacent vertebral bodies by more than two mm. Disc protrusion has been identified as an asymmetric focal expansion of the disc tissue beyond the vertebral body margin. Disc extrusion was characterized as disruption of the annulus' outer fibers, and the abnormality of the disc was typically greater in its anteroposterior dimensions than at its base. Sequestration was described as an extruded disk material that lost its parent disk connection.

NRC on MRI was characterized as the obliteration of the epidural fat plane by a herniated disk in the medial, lateral or both aspects of the nerve roots, any change in nerve root thickness compared to the opposite nerve root, or any displacement of nerve root.

AT on MRI was classified on T2 weighted images as a zone of hyperintensity and on T2 weighted images as a region of iso-intensity or hypo-intensity, located in the annulus fibrosus not extending up to the nucleus pulposus.

Lumbosacral spine MRI was conducted with a 1.5-T scanner (GE Medical Systems, Milwaukee, WI, USA). Two imaging sets were acquired for each patient. Routine complete protocol included T1W spin echo (SE) images in the sagittal plane, fat suppression sequence in the sagittal plane and T2W strong spin echo (FSE) images in the sagittal and axial planes while minimal protocol included T2W FSE in the sagittal and axial planes. Both studies were interpreted by a consultant radiologist with more than 5 years' experience in reporting MRI scans of lumbosacral spine.

Statistical analysis for social sciences (SPSS version 24), Inc, USA was used for the purpose of statistical analysis. The association of dependent variable (disc herniation) with independent variables like age, gender, NRC, and AT. P-value <0.05 was taken as significant. Diagnostic accuracy of minimal lumbar spine MRI procedure in the diagnosis of lumbar disk herniation, nerve root compression, and AT was also explored using routine MRI as a standard of reference. Sensitivity, specificity, negative predicted value (NPV), positive predicted value (PPV), and overall diagnostic accuracy was measured.

RESULTS

A total of 916 patients were included in the study. The mean age of the patients was 38.77±13.12 years (20-81 years). Majority (n=589, 64.3%) patients were presented with ≤40 years of age whereas 327 (35.7%) patients were presented with >40 years of age. There were 476 (51.9%) males 440 (48.03%) females.

The sensitivity and specificity of limited protocol disc herniation, limited protocol NRC and limited protocol AT was found to be 100% taking full protocol disc herniation, full protocol NRC and full protocol AT respectively.

Disc herniation was observed in 645 (70.41%) patients. However, in most of the patients, disc herniation was observed at various levels. In total 919 disc herniations was observed, of these, disc bulge was observed in majority (n=751, 63.6%) of the patients followed by protrusion (n=152, 12.9%), extrusion (n=14, 1.2%) while sequestration was observed in only 2 (0.2%) patients. Level of disc herniation showed that L4/L5 level was observed in majority (n=410, 44.73%), followed by L5/S1 (n=414, 44.61%), L3/L4 (n=63, 6.85%), L2/L3 (n=26, 2.82%), while L1/L2 in only 6 (0.65%) patients.

NRC on limited and full protocol showed that there were 380 true positive and 801 true negative cases. Among these 380 positive cases, bilateral site was found higher (n=338, 88.94%) followed by left side (26, 6.84%) and right side (n=16, 4.21%). Level of NRC showed that L5/S1 NRC was found higher (n=215, 56.57%) followed by L4/L5 (n=131, 34.47%), L3/L4 (n=20, 5.26%), L2/L3 (n=12, 3.15%) while only 2 (0.52%) patients were presented with L1/L2 nerve root compression.

Annual tear on limited and full protocol showed that there were 92 true positive and 1089 true negative cases. Level of annual tear showed that L5/S1 level was found higher (n=58, 63.04%) followed by L4/L5 (n=26, 28.26%) while L3/L4 were presented in 8 (8.69%) patients.

A significant difference of disc herniation was observed with age (p-value <0.001), gender (p-value 0.011), NRC (p-value <0.001), and annual tear (p-value <0.001). **(Table I)**

TABLE I: COMPARISON OF DISC HERNIATION WITH GENERAL CHARACTERISTICS OF THE PATIENTS (n=654)^

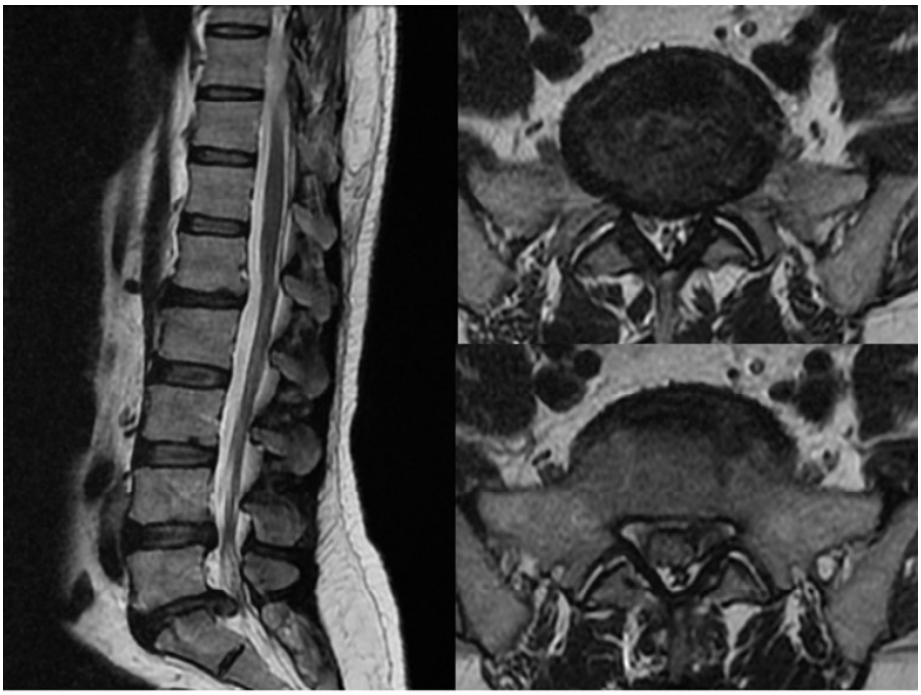
	Disc Bulge	Extrusion	Protrusion	Sequestration	p-value
	n (%)	n (%)	n (%)	n (%)	
Age, years (n=654)					
≤40	292 (86.1)	0 (0)	47 (13.9)	0 (0)	<0.001
>40	238 (75.6)	14 (4.4)	61 (19.4)	2 (0.6)	
Gender (n=654)					
Male	226 (75.8)	8 (2.7)	62 (20.8)	2 (0.7)	0.011
Female	304 (85.4)	6 (1.7)	46 (12.9)	0 (0)	
Nerve root compression (n=919)					
Yes	287 (75.5)	14 (3.7)	77 (20.3)	2 (0.5)	<0.001
No	464 (86.1)	0 (0)	75 (13.9)	0 (0)	
Annual tear					
Yes	52 (56.5)	0 (0)	40 (43.5)	0 (0)	<0.001
No	699 (84.6)	14 (1.7)	112 (13.6)	1 (0.1)	

Chi-square test was applied, p-value <0.05 was taken as significant

^Disc herniation was observed at various level in single patient in majority of the cases. However, total number of patients with disc Herniation was 654

Figure I: MRI sagittal T2 view and axial T2 (taken at L4/L5 level) demonstrates diffuse disc bulge causing thecal indendation and mild left sided neural formamina narrowing resulting in mild left sided nerve root compression at this level

Figure II: MRI sagittal T2WI and axial T2WI (taken at the level of L%/S1). Sagittal T2WI shows multilevel disc degeneration in lumber spine, more marked at L4/L5 and L5/S1 demonstrates disc extrusion with inferior migration



DISCUSSION

With an increase in life expectancy and increasing population age, the prevalence of DDD as well as clinical disability related to disc degeneration is also on the rise. LDH is an important aspect of DDD. Advent of MRI has led to a change in management trend of DDD. Following clinical examination, MRI may help in diagnosis of NRC thus making it a suitable investigation in patient under consideration for surgery[11]. Current study was an attempt to evaluate the use of axial and sagittal T2 weighted images (T2WI) as a limited protocol for evaluation of LDH, radiculopathy and AT in a country where majority of the population belong to a lower or middle class socioeconomic status[12]. In evaluating the stated sequences as limited protocol in comparison to routine MRI, we found that findings were identified without any appreciable loss of information.

The findings of this study report a high accuracy in diagnosis of LDH. In contrast, Chawalparit et al[8] reported a lower accuracy of limited protocol in diagnosis of LDH. A potential reason for this could be the use of only sagittal T2WI for diagnosis. Moreover, another study by Muller et al[13] also utilized sagittal T2 for a limited protocol and showed lower sensitivity in detection of thecal sac indentation. Thecal sac indentations usually occur as a result of disc herniation and utilization of sagittal and axial T2WI images as a limited screening protocol could improve detection of LDH resulting in higher accuracy.

Results of our study show that utilization of sagittal and axial T2 as a limited protocol has a high accuracy in diagnosis of NRC which is commonly occurred as a result of LDH. Previous studies[8,13] show that results of limited protocol are less satisfactory in comparison to our results. Utilization of only sagittal T2 images could also be a potential factor in low sensitivity and specificity in diagnosis of NRC. Axial T2WI, in addition to sagittal T2WI, can provide more useful information for detection of NRC. Robertson et al[14] also evaluated NRC utilizing similar sequences as used in our study however their results were also not much satisfactory. This can be due to the fact that in the study by Robertson et al, the scanning protocol of limited and full protocol were different. They utilized small matrix size, thicker slices and a relatively shorter acquisition time that could have resulted in less acceptable results due to poor spatial resolution and image quality. There was no change in parameter in our limited and routine protocol MRI thereby leading to no change in quality of image or spatial resolution.

We observed a higher sensitivity and comparable specificity of limited protocol in diagnosis of AT in comparison to those reported earlier by Muller et al[13] AT appear as a zone of high signal intensity in annulus fibrosus on fluid sensitive sequences (T2WI). In 1992, the term “high intensity zone” was coined to describe a T2 hyperintense area in posterior annulus fibrosus[15]. These have been described as MRI biomarker for the low back pain[16-18]. Concurrent use of axial and sagittal T2WI in our study as opposed to sagittal T2WI used by Muller et al could have led to an increased sensitivity in AT depiction.

Aging and degeneration are important causes of disc herniation. LDH and DDD are usually diagnosed coexistently. In the current study, we were able to show that disc herniation has a significant association with age. DDD is the condition that may be the etiology of underlying LDH. The results of our study are comparable to those reported by Siemionow et al[19]. Siemionow et al described a direct relation of age with disc degeneration and a good correlation between age and disc degeneration. Moreover, it can also be hypothesized that engaging in laborious work at an early age can lead to disc herniation and DDD. Our results also report a significant association of disc herniation with gender, but these findings are not comparable to those reported in earlier[19]. It can be postulated that ethnic differences may be responsible.

According to a study[20] patients undergoing MRI with a limited protocol are satisfied more than those patients who have undergone plain radiography. This satisfaction was related to a reduction in hospital referrals, reduction in cost spent on additional tests and a better reassurance resulting in an improved

life quality. Another potential advantage could be in terms of claustrophobia i.e; claustrophobic patients can rapidly undergo this MRI and have a proper evaluation for lower back symptoms.

MRI protocols that are time efficient and cost effective have a great potential in musculoskeletal imaging. Limited MRI protocols have been explored in evaluation of different musculoskeletal regions such as hips[21,22] and cervical spine[23] and have yielded acceptable results. In developing countries like Pakistan, such protocols can help improve the patient care by limiting the cost.

Our study was not without certain limitations. An important limitation in our study was that we utilized routine full protocol MRI lumbar spine as standard reference and did not have any surgical correlation. Another potential limitation was that MRI observations were made by a single observer and we did not evaluate the interobserver reliability of the limited protocol. Different observers have different way to interpret lumbar spine imaging findings. Observer variability and ways to minimize this variability can aid in improvement of diagnosis and provides an effective measure of communication between radiologist and clinician.

Despite these limitations, we believe that results of current study carry a potential role in evaluation of disc herniation, NRC and AT. Adequate diagnosis early can save the patient from undergoing time consuming expensive investigations. Carrying almost no ionizing radiation and soft tissue results better than plain radiography, limited protocol MRI should be considered as an initial imaging technique in symptomatic patients. However, it is recommended that further multicentric studies should be carried out to generalize the results of limited protocol MRI. Moreover, it is also recommended that patients having non-conclusive limited MRI should undergo routine full MRI study for further evaluation. Furthermore, patients having suspicion of any infective or neoplastic disease process should undergo evaluation with full MRI study directly, preferably with contrast, to make adequate diagnosis possible.

CONCLUSION

Utilization of axial and sagittal T2 weighted images as a limited protocol can lead to a diagnosis of LDH, NRC and AT with high accuracy without causing any loss of information. However, for evaluation of infections or neoplasms, a direct evaluation with routine full protocol MRI with contrast should be performed.

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AUTHOR CONTRIBUTIONS

Shaikh RG: Designing and conception of study, data accusation, drafting of manuscript

Hussain M: Designing and conception of study, final approval of manuscript

Khan SA: Review of the manuscript for important intellectual content, final approval of the study

Sattar A: Review of the manuscript for important intellectual content, final approval of the study

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