ORIGINAL RESEARCH

Diagnostic Value of 3D Fiesta Sequence in Imaging of Lumbar Radiculopathy

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ABSTRACT

Introduction: Low-back pain (LBP) is a common cause of disability in our society. The DDx for low back pain comprises mechanical, non-mechanical, and visceral causes which includes for example degenerative disc disease, spondylolysis, spondylolisthesis, spinal stenosis. MRI is the method of choice for radiological evaluation of the spine. MRI is very sensitive in detecting anatomic changes that could cause a radiculopathy with excellent soft tissue contrast. Therefore, Most patients with features of lumbar radiculopathy are referred for other radiological and neurological examination, MRI can be used as the initial modality of choice. This study is being conducted for establishing a new protocol for lumbar radiculopathy and to document the superiority of 3D FIESTA over Conventional MRI Protocol.

Materials and methods: The study was divided into two groups. The control group consisted of 15 healthy volunteers and the experimental group consisted of 58 patients**.**

Results: In all patients who were evaluated in our study with both FSE T2W and 3D FIESTA sequences statistically the visibility of the evaluated structures and lumbar radiculopathy was excellent for axial 2D T2w TSE and axial 3D FIESTA (MPR) (74.2, 100 percent) respectively. As the visualization of the normal structures were comparatively excellent for 3D FIESTA with good spatial resolution and adequate T2/T1 ratio.

Conclusion: The detection of lumbar radiculopathy in terms of each affected dermatomes has always proved to be a diagnostic challenge both for the physician and the radiologist, the use of 3D FIESTA sequences has greatly enhanced detection rates.

Keywords: Disc Degeneration, Lumbar Disc Disease, Lumbar Region, Lumbar Stenosis, Magnetic Resonance Imaging, Neuralgia, Recurrent Low Back Pain, Spinal Cord, Three-Dimensional Image.

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INTRODUCTION

Low-back pain (LBP) is a common cause of disability in our society.[1] Pain in the lower back can have many origins. The differential diagnosis for low back pain comprises mechanical, non-mechanical, and visceral causes and includes for example degenerative disc disease, spondylolysis, spondylolisthesis, spinal stenosis, spondylodiscitis.[2]

A lumbar radiculopathy is characterized by a radiating pain in one or more lumbar dermatomes.[3] Radiculopathy is caused due to spinal nerve compression, this may be due to herniated disc or osteophyte formation. Patient will present with neurological deficits such as weakness and diminished reflexes in specific dermatomes which leads to sensory loss. MRI used as a choice of modality for diagnosis and provides road map for conservative treatments.[4]

It can be divided into structural and non-structural.

Structural causes include any process that causes mechanical compression of nerve root, such as herniated disc and of degenerative diseases (osteophyte) of spine.

Non-structural causes include diabetic radiculopathy which likely occurs due to infarction of a nerve root or herpes zoster causes radiculopathy due to viral mediated inflammation of the nerve root.[5] Magnetic resonance imaging (MRI) is the method of choice for the evaluation of the spine. MRI provides an excellent soft tissue contrast which is non-invasive and without ra-

diation. Therefore, MRI is very sensitive in detecting anatomic changes that could cause a radiculopathy.[7,8] Most patients with features of lumbar radiculopathy are referred for other radiological and neurological examination. Hence this study is being conducted to create an understanding about the role of MRI 3D FIESTA Sequence in imaging of lumbar radiculopathy, to establish a working protocol for referring consultants and to document the superiority of 3D FIESTA over Conventional MRI Sequences.

In this study, lumbar radicular pain is considered as pain radiating into one or more dermatomes caused by nerve root irritation and compression.[6]

Imaging techniques in relation to lumbar radiculopathy usually refer to lumbosacral spine radiography, computed tomography (CT) scan, and magnetic resonance imaging (MRI).

MATERIALS AND METHODS:

Study was conducted at Chettinad Hospital & Research Institute**.** Two groups of patient were examined separately and evaluated by two different radiologists.

The study included 15 control patients and visibility of the structures in lumbar spine was scored independently with 5 point confident scale. 58 experimental patients with clinical suspicion of lumbar radiculopathy were imaged and the disease was given by grading.

Control group

The lumbar spines of 15 healthy volunteers, 7 male and 8 female, and aged from 24 to 38 years (mean age, 28.4 years) were examined.

Visibility of anatomical structures in each sequence was assessed qualitatively using a five-point confidence scale: 1. not visible, 2. barely visible, 3. adequately visible, 4. good visibility, 5. excellent visibility. (Figure-1) Evaluated structures concerning visibility was good for axial 2D T2w TSE, axial 3D FIESTA, (k=0.64, k=0.61). Visibility was good for Sagittal 2D T2w, Sagittal 3D FIESTA MPR (k=0.86, k=0.89). (Figure-2)

Experimental group

The lumbar spines of 58 experimental patients using simple random sampling and it was calculated with department's routine workload, 28 male and 30 female, and aged from 20 to 58 years (mean age, 39.5 years) were examined. Grading was done as given below.

Grading System

The system we used in grading compromise of the intraspinal extradural lumbar nerve root consists of four grade categories, they are Grade 0 (abutting): nerve root is preserved and compromise is seen. No evidence of nerve root contact with the disk material and the disk material is preserved. Grade 1 (indenting): nerve root is not preserved that is a minimal contact disk material noted. The position of the nerve root is normal. Grade 2 (impingement): Nerve root is displaced by the disk material. Grade 3 (compression): Nerve root is sandwiched between disk material and the wall of the spinal canal.

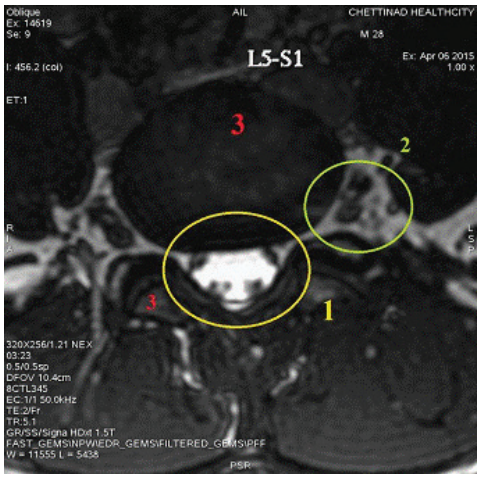

Figure-1: Axial 3D T2w FIESTA image of the lumbar spine at the level of the neural foramen L5/S1 depicting the intraspinal nerve roots (1), neural foramen, foraminal fat, intraforaminal structures (2), and vertebral bone, intervertebral disc, and facet joints (3)

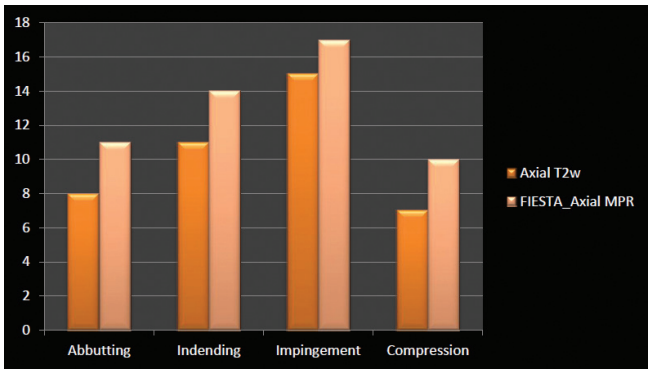

Figure-2: Bar graph showing statistical comparison of the T2w Axial and FIESTA axial (MPR) Sequence

Both the Control study and experimental patients were scanned using a 1.5 Tesla SIGNA GE HDxt MRI scanner. Two readers reviewed independently reviewed all volunteer's images for qualitative analysis on an independent AW® workstation (GE), with multiplanar reconstruction.

Image Acquisition and Image Processing

All our patients were imaged on a 1.5-T clinical scan-

Parameters	T2W-FSE	T1W-FSE	STIR-FSE	T2W-FSE	T2W-FSE	FIESTA
Mode of Acqusition	2D	2D	2D	2D	2D	3D
Plane	Sagittal	Sagittal	Sagittal	Axial	Axial	Coronal
FOV(mm)	28	28	28	20	20	28
TR(ms)	4320	880	4675	3360	630	4.9
TE	11	9.6	26	85	10	1.9
Matrix	385x256	384x224	384x224	385x256	384x224	320x256
Slice thickness (mm)	3	3	3	3	3	1
Interslice spacing (mm)	0.5	0.5	0.5	0.5	0.5	-

Table-1: Parameters and sequences used for this study

Sequence	T2E TSE – 3D FIESTA	T2W TSE – 3D FIESTA
Orientation	Sagittal	Axial
Abutting	0.257	0.316
Indending	0.12	0.17
Impingement	0.317	0.42
Compression	0.180	0.299

Table-2: Table showing statistical comparison of T2E TSE – 3D FIESTA in both Sagittal and axial planes.

Figure-3: a)Sagittal T2w demonstrating of the L5 traversing nerve root on the left side, b)axial T2 demonstrating impingement of the left traversing L5 nerve root on left side, c) Axial MPR FIESTA demonstrating L5 traversing root compression on both the side, d) Sagittal MPR FIESTA Demonstrating impingement of the left traversing nerve root.

ner (GE). An 8-channel phased array spine coil was used. (Table 1)

Ethical consideration

The research proposal was approved by the institutional human ethical committee of Chettinad Academy of Research and Education. The investigator explained the study to the research participants and obtained an informed consent form prior to the data collection procedure.

(IHC/05/12 Dec 2014/ Desp.no 443/31.01.2015)

The study sample was the young and mid aged adults who had low back ache. This study was carried out using simple random sampling technique. The study was divided in Control and Experimental group in which 58 were in experimental group and 15 in control group. The data of the present study was analyzed based on specific objectives. This was a prospective study. The data obtained from the 58 samples was analyzed by using descriptive and inferential statistics by SPSS 20th version.

STATISTICAL ANALYSIS

Statistical comparison of the evaluated sequences concerning lumbar radiculopathy (Wilcoxon matched-pairs signed-ranks test)

RESULT

Axial 3D MPR FIESTA images showed significantly difference ($p < 0.03$) when compared to axial 2D T2W (Abutting, p=0.04, indenting p=0.04, Impingement, p=0.003 and Compression p=0.005, respectively) (Figure-3)

74.2, 100 percent of radiculopathy were showed respectively in T2W, 3D-FIESTA, in our study with both FSE T2W and 3D FIESTA sequences statistically the visibility of the evaluated structures and lumbar radiculopathy was excellent for axial 2D T2w TSE and axial 3D T2w FIESTA (MPR). (Table-2)

DISCUSSION

In this imaging study of lumbar radiculopathy, nerve exit from the cord and cauda equina at each foraminal levels were successfully demonstrated with 3D FIES-

TA sequences. The majority of the patients had L5-S1 Disc bulge causing impingement of the traversing nerve root which was clearly demonstrated by 3D FIESTA sequence.

In routine T2w as slice thickness increases resolution was be better, but the probability of missing the findings was more whereas in 3D FIESTA it provides an isotropic image resolution and good contrast between the structures. Likewise the sensitivity of grading in T2w is comparatively less than 3D FIESTA sequence. It is far quicker, more comfortable, and safer for the patients. MR has the additional benefits to demonstrate excellent evaluation of the marrow space.[9]

The major concern regarding of 2D MR imaging techniques in diagnosing lumbar disease is its inability to reveal foraminal disease accurately because of thick imaging slices and limited views of exiting nerve roots in the axial plane the overall examination times have reduced with GE imaging.

Three-dimensional MR imaging techniques allow depiction and delineation of anatomical details within the imaged volume and are a prerequisite for successive three dimensional reformations in arbitrarily chosen spatial orientations.[10] The three-dimensional FIESTA sequence in this study combines high spatial resolution and T2 contrast within an acceptable examination time by using long echo trains with short echo spacing and parallel imaging.

A 3D technique overcomes theses problem that allows short TEs with this contiguous slice and allowing reformation in any desired arbitrary plane. This was made possible with GRE sequence.[11] As a result of the higher spatial resolution of 3D FIESTA, the intraspinal nerve roots, and the neural foramen and its structures were better visible and distinguishable compared to 2D T2w TSE.

In addition, the isotropic data set of coronal T2w FIESTA offers the possibility of high-quality retrospective reformations in every orientation. Axial reformations of the coronal 3D FIESTA data set provide excellent contrast between CSF, spinal cord, and vertebral bone with distortion-free display of the anatomic structures. The visibility of all evaluated structures except cord anatomy was superior or equivalent to 2D T2w TSE. The 3D T2w FIESTA data set originally was acquired in coronal orientation. Sagittal reformations of originally acquired 3D FIESTA images provided suboptimal results due to minimal artifacts. The examination time of 3D FIESTA is substantially longer than that of T2w weighted sequences despite acceleration of the image acquisition by parallel imaging.[12,14]

One essential prerequisite for exploring the potentials of three-dimensional imaging is a software tool with 3D interactive multiplanar reformation capabilities that provides the maximum information of the volume dataset.

The potentials of the 3D FIESTA sequence can only be utilized if the patient is able to tolerate the longer examination time so that no artifacts occur that would degrade 3D reformations.[15]

CONCLUSION

Diagnosis of lumbar radiculopathy is helpful for patients and clinician in understanding, monitoring and treatment of the disease. For lumbar radiculopathy, fiesta allows the good visualization of the intradural lumbar roots, and might be useful for a more general evaluation of lumbar degenerative disease when combined with a technique better suited for evaluation of the foramina, such as axial FSE and 3D GRE.

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