wjpmr, 2020,6(9), 37-41

SJIF Impact Factor: 5.922

WORLD JOURNAL OF PHARMACEUTICAL AND MEDICAL RESEARCH

www.wjpmr.com

Research Article

ISSN 2455-3301

WJPMR

STIR VERSUS T1/T2 WEIGHTED IMAGES TO EVALUATE ABNORMAL ENDPLATE SIGNAL IN THE LUMBAR SPINE

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Article Received on 15/07/2020 **Article Revised on 05/08/2020** **Article Accepted on 26/08/2020**

ABSTRACT

Purpose: To compare STIR with T2-/T1-weighted (T2W/T1W) images in detecting abnormal endplate signal in the lumbar spine (L. spine) in patients presenting with back pain. **Subjects and methods:** After obtaining IRB exemption, we retrospectively reviewed 50 routine clinical lumbar MR studies of patients with back pain. All patients underwent MRI on 1.5T or 3T scanners. All scans consisted of sagittal T1W, T2W, and STIR sequences as well as axial T2W sequences. Patients with a history of lumbar spine surgery, infection, or neoplasm were excluded from this study. We evaluated a total of twelve endplates in each patient from T12-S1 levels. We recorded whether abnormal signal was present on T2W/T1W sequences, STIR sequences or both sequences. Modic type change was recorded for each endplate based on the appearance on T2W and T1W images. **Results:** There were 24 male and 26 female patients with ages ranging from 25 to 85 years. Abnormal STIR signal in the endplates was seen in 22% of all endplates in the lumbar spine. Abnormal T2W/T1W signal in the endplates was seen in 20.8% of all endplates. 4.7% of all endplates demonstrated abnormal signal only on STIR images. 5.2% of all endplates demonstrated abnormal signal only on T1W/T2W images. Overall, 8% of patients had abnormal findings only on STIR images, and 8% of patients had abnormal findings only on T1W/T2W images. Abnormal STIR signal was present in 83.3%, 72.3% and 91.7% of L. spine endplates that demonstrated Modic type I, II and III changes, respectively. **Conclusion:** STIR and T1W/T2W images provide complimentary, but sometimes different information about endplate integrity in the L.spine. Spine MRI protocols may benefit from the addition of STIR or other fat saturated fluid sensitive sequences to conventional T1W/T2W images to maximize MR sensitivity for detection of endplate pathology.

INTRODUCTION

Modic classification of endplate changes in patients with back pain is widely used and is likely the most well-known system for grading endplate disease in patients with back pain. This classification system is based on the appearance of endplates on non-fat saturated T1W and T2W images. STIR images are also obtained by many imaging centers as part of routine lumbar spine MRI.

The purpose of this project was to investigate whether the endplate changes detected on STIR sagittal images correlate with abnormalities seen on conventional T1W and T2W spin echo sagittal images. We also evaluated whether bone marrow edema detected on STIR images corresponded to Modic type 1 change only, or whether it can be seen in other types of Modic changes.

SUBJECTS AND METHODS

Our institutional review board exempted this study from full review as the study involved only retrospective review of images and records. The study was conducted in a HIPAA compliant fashion.

We retrospectively reviewed 50 routine clinical L.spine MR studies of patients who presented to our institution for evaluation of back pain between September of 2015 and March of 2016. The L. spine MRI studies were selected in a random fashion, but with a date at least three months prior to the review time to minimize recall bias. Patient age, sex and history were obtained from clinical data section of our PACS and from electronic medical records. Patients with a history of lumbar spine surgery, spine infection, or spinal neoplasm were excluded from this study.

All patients underwent MRI on 1.5T (Siemens Healthcare Espree, VB17) or 3T (Philips Healthcare Ingenia, v5.1) scanners. Our routine clinical non-contrast enhanced lumbar spine.

MRI scans (Table 1) consisted of sagittal T1W images (TR=600-700, TE=7-14), T2W images.

(TR=4000-4400, TE=60-125), STIR images (TR=3300-3500, TE=50-70), and axial T2W images (TR=3000-3800, TE=100-120). All sequences were obtained using 4 mm slice thickness and 0.4 mm slice gaps. The field of view was 25-26 cm on sagittal images and 18 cm on axial images.

A musculoskeletal radiologist with 7 years of experience and a radiology resident evaluated a total of twelve endplates in each patient from T12-S1 levels in consensus. We recorded whether abnormal signal was present on T1W/T2W images, STIR or both sequences for each endplate. Modic type change was recorded for each endplate based on the appearance on T2W and T1W images.

RESULTS

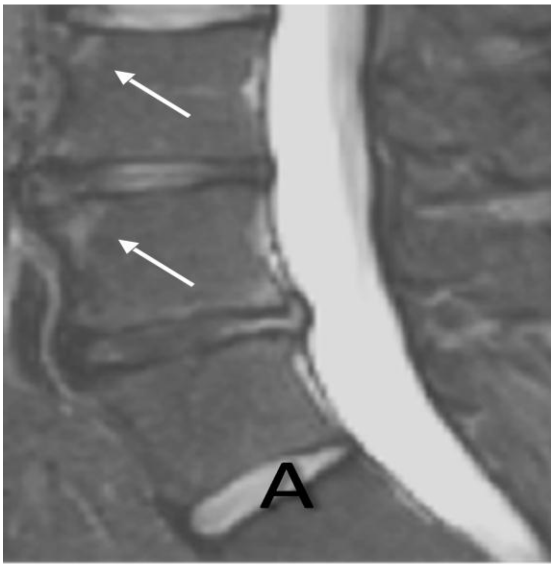
There were 24 male and 26 female patients with ages ranging from 25 to 85 years. The majority of clinical indications specified "low back pain" as the reason for L. spine MRI study. Other indications included "chronic back pain," "dorsalgia," "radiculopathy," "back pain without sciatica," "lower back with hip pain," "back pain with lower leg and feet pain," and "ataxic gait." Laterality of pain was specified in three of the 50 patients' provided histories.

Abnormal STIR signal in the endplates was seen in 132/600 (22%) of all endplates. Abnormal T1W/T2W signal was seen in 125/600 (21%) of all endplates. 28/600 (4.7%) of all endplates demonstrated abnormal signal only on STIR images. 31/600 (5.2%) of all endplates demonstrated abnormal signal only on T1W/T2W images.

Overall, 8% of patients (4 of 50) had abnormal findings only on STIR images, and 8% of patients (4 of 50) had abnormal findings only on T1W/T2W images.

Modic I change was found in 30/600 (5%) endplates, Modic II change was found in 83/600 (14%) endplates, and Modic III changes was found in 12/600 (2%) endplates.

Abnormal STIR signal was present in 25/30 (83.3%), 60/83 (72.3%), and (11/12) 91.7% of endplates that demonstrated Modic type I, II, and III changes respectively.



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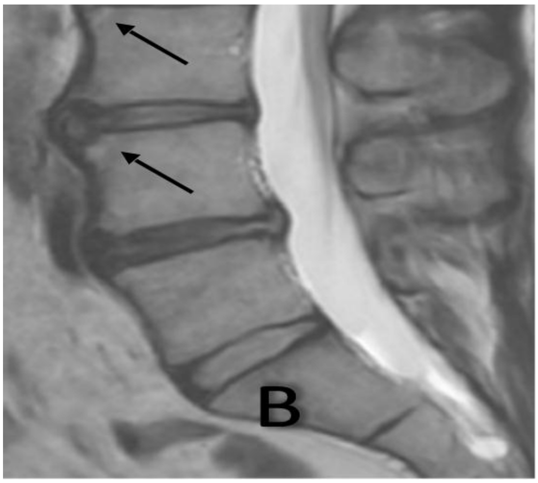

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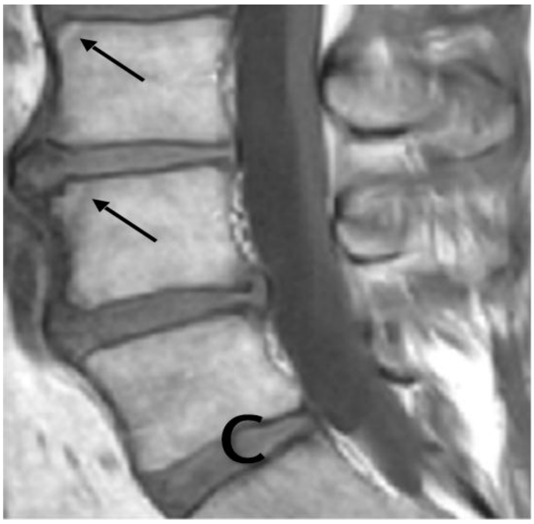

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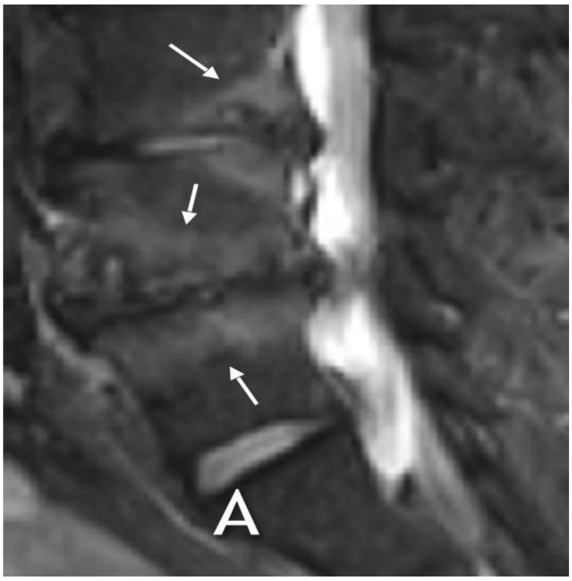

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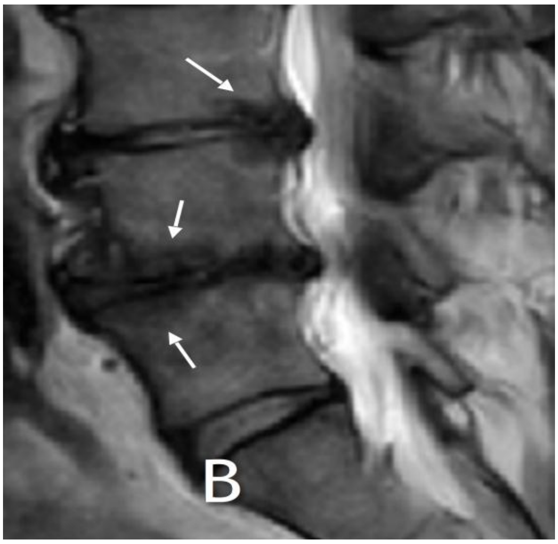

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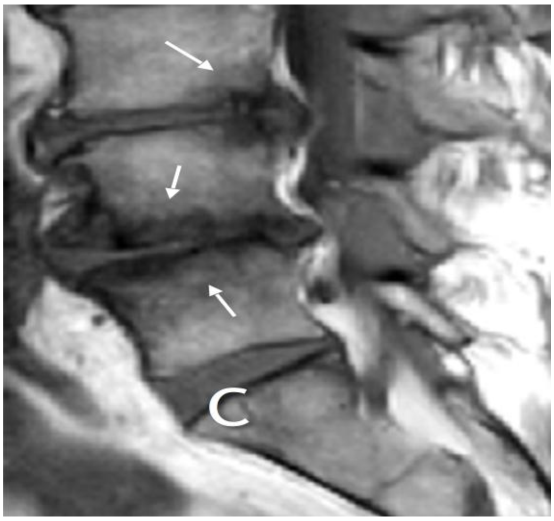

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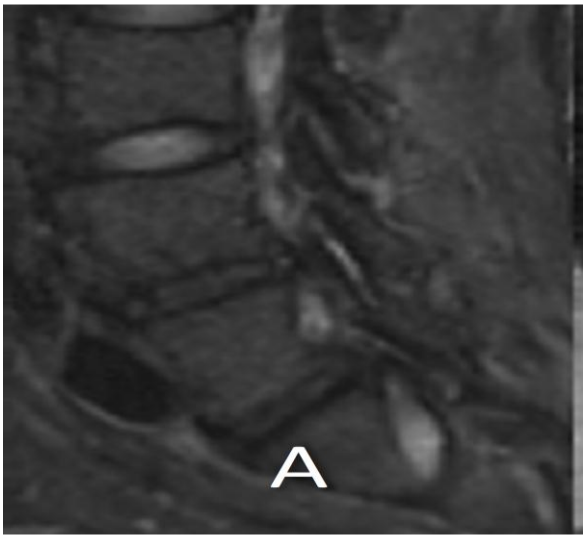

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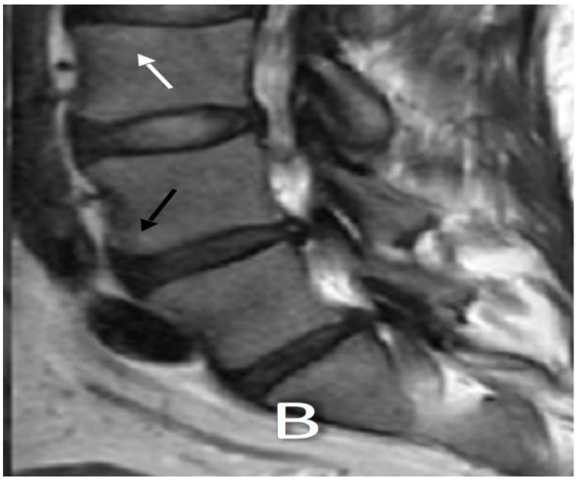

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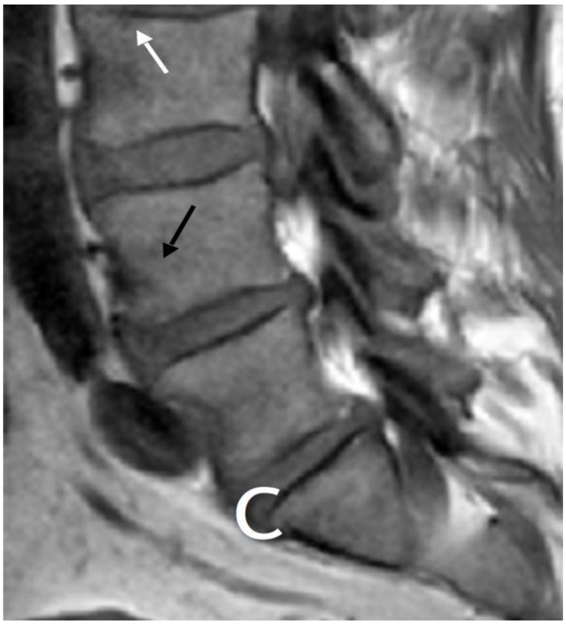

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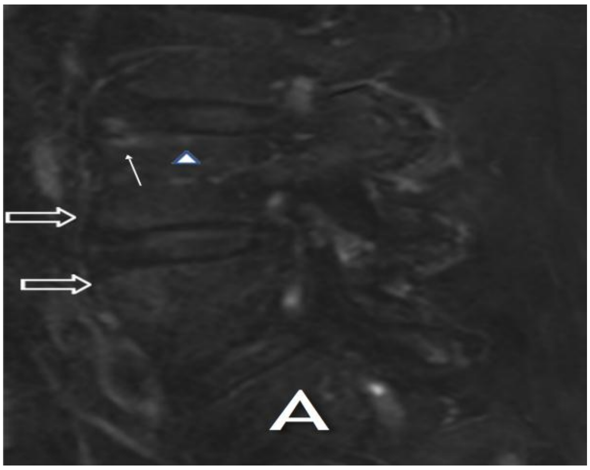

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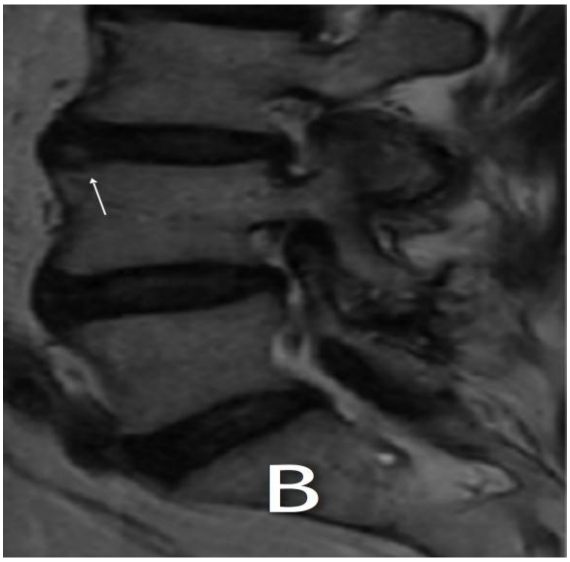

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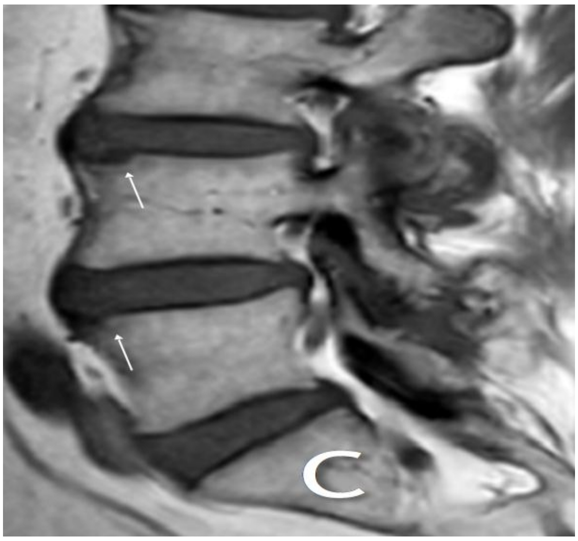

Figure 4.c:

DISCUSSION

Deroos et al. published description of lumbar endplate changes associated with degenerative disk disease on MRI in 19871. In this initial paper, deRoos' hypothesis proposed that hypointense signal on T1W images and hyperintense signal on T2W images correspond to increased water content in the endplates, hyperintense signal on T1W and T2W represents fatty marrow conversion, and hypointense signal on T1W and T2W images represents fibrosis and possibly thickened trabeculae in the bone marrow.[1] The following year, Modic et al. correlated imaging findings with histology and initially published results with description of type I and type II changes, and later added type III into the classification system in a review article published the same year.[2,3] Based on the appearance of end plates on histological samples, Modic was able to confirm that Modic type I change corresponds to proliferation of fibrovascular tissue and Modic type II change corresponds to fatty replacement in the endplates.[2] Modic type III changes were termed as such based on the sclerotic appearance of endplates on radiographs[3]

deRoos et al. described T1W and T2W images in their study with no mention of fat saturation or inversion recovery techniques1. Modic et al. also primarily used non-fat saturated T1W and T2W sequences in their original study as primary sequences.[2] They did utilize chemical shift imaging with a modified Dixon technique to determine relative lipid/water contributions to the signal on a subset of patients with Modic type II change. Modic et al published a review article in 1988 about imaging lumbar spine with MRI in 1988, where they discuss various T1W and T2W MRI techniques, but do not mention fat saturation or inversion recovery techniques.[3]

ACR (American College of Radiology) guideline document revised in 2012 lists T1 and T2 weighted sagittal images as part of minimum requirements.[4] While the option of suppressing fat signal is part of the general discussion in the ACR guideline paper, whether or not fat should be suppressed on T1W or T2W images is not specifically addressed in the minimum requirements paragraph.

Nevertheless, the utility of STIR images for detection of bone marrow lesions is well established5, and many centers use sagittal STIR sequence in their routine lumbar spine MRI protocols. Clinical use of STIR was described in scientific literature as early as 1985 by Bydder.[6]

Recently, STIR imaging of the spine has been mentioned in various publications in the evaluation of lumbar spine. The Assessment in Spondyloarthritis International Society– Outcome Measures in Rheumatology (ASAS/OMERACT) published a consensus paper that heavily relies on STIR appearance of endplates in the setting of axial spondyloarthritis.[7] Studies that mention use of STIR imaging also include work that evaluated facet joints,[80] comparison of contrast enhanced imaging and STIR images,[9] imaging of infection,[10] and evaluation of neoplasms in the spine.[11]

To our knowledge, this is the first study to formally compare STIR images with T1W/T2W images in the evaluation of end plate changes as related to degenerative disk disease of the lumbar spine. We demonstrate that there is a subset of patients who demonstrate abnormal signal only on STIR images and another subset of patients who have abnormal endplate signal only T1W/T2W images. We also demonstrate that in addition to expected hyperintense appearance of endplates on STIR images that corresponds to Modic type I change, STIR hyperintense signal can be seen in Modic type II (Figure 1) and Modic type III (Figure 2) changes. Some endplates with type I change on T1W/T2W images do not demonstrate hyperintense STIR signal (Figure 3).

The differences in appearance of endplates on STIR and T1W/T2W weighted images may be related to several factors. In some cases, saturation of fat may result in better delineation of edema and hyperemia. In others, higher signal to noise ratio of conventional T1W and T2W sequences may explain cases where abnormalities are only seen on T1W/T2W weighted images.

Presence of STIR signal in type II and type III Modic changes suggests that bone marrow edema and hyperemia may be present in later stages of disease. There may be several stages of Modic changes present in any given endplate at any given time. Figure 4 demonstrates that while some of these are located in exactly the same physical location in the endplate, there may be some cases where STIR signal abnormality exists in a location different from Modic changes on T1W/T2W images.

We did not systematically compare extent and exact location of abnormal signal in the endplates on different sequences in this study. Other weaknesses of our study include lack of several observers. We could not determine interobserver agreement in our study as images were reviewed in consensus by both authors. Our study did not have correlation with histological analysis to confirm presence of endplate changes on microscopy. Since this is a single institution study, applicability of the results to the broad population may be limited. We did not evaluate T2W with fat saturation images or DIXON sequences in our study. It may be worthwhile to compare STIR images to these techniques as sensitivity may again be different.

CONCLUSION

Conventional non-fat saturated T1W/T2W images and STIR images provide complimentary, but at times different information about changes in the lumbar endplates. Inclusion of sagittal STIR images in routine non-contrast MRI protocol for evaluation of back pain can reveal additional information in some patients.

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