

## The Role of Fat Saturation Technique in Lumbar MRI Evaluation of Herniated Nucleus Pulposus Disease: A Case Study

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### ARTICLE INFO

*Keywords:* Fat Saturation, Lumbar MRI, HNP

*Received:* 3, January

*Revised:* 24, January

*Accepted:* 26, February

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### ABSTRACT

Herniated Nucleus Pulposus (HNP) is the most common cause of low back pain and a leading indication for spine surgery. At Radiology Department of Hospital X Semarang, an additional T2 TSE Sagittal Fat Saturation (FS) sequence is used in lumbar MRI to enhance diagnostic accuracy. This qualitative case study, conducted in May 2024, involved observations, documentation, and interviews with radiographers. The T2 TSE Sagittal Fat Saturation sequence highlights intervertebral discs more clearly by suppressing surrounding fat, making it easier to detect abnormalities like disc herniation and tears. The use of this sequence improves visualization of disc pathology and grading, offering more optimal diagnostic information in HNP cases.

## **INTRODUCTION**

Magnetic Resonance Imaging (MRI) is a non-invasive diagnostic technique that uses magnet to produce medical images medis (Nova Setiyanto & Nur Mayani, 2020). One of the most common MRI examination is Lumbar MRI, which is used to determine the condition of the Lumbar region. Lumbar MRI examination is often used in various cases, such as Hernia Nucleus Pulposus (HNP), Radiculopathy, Myeloradiculopathy, and TB Spondylitis (Meita Astari, 2017).

HNP is one of the most common causes of lower back pain (Azharuddin et al., 2022), especially in the elderly population (Mbarki et al., 2020). HNP cases generally occur in the lumbar vertebrae, especially at the L4-L5 and L5-S1 levels. HNP occurs due to the descent of the annulus fibrosus content from the intervertebral disc into the spinal cord, with pressure from the nucleus pulposus causing compression of the nerve elements (Yogi & Jeniyanthi, 2024). The most sensitive imaging modality for diagnosing HNP is Magnetic Resonance Imaging (MRI), which offers detailed anatomical visualization without exposure to ionizing radiation (Harmawan et al., 2022). MRI is more effective than CT scan in differentiating inflammatory, malignant, or inflammatory etiology of herniated nucleus pulposus.

The standard protocol for a lumbar MRI examination includes a series of sequences, starting with a T1-weighted sagittal to evaluate the anatomy of the spine and intervertebral discs (Ildsa et al., 2019), and T2-weighted sagittal to assess disc hydration status and detect herniation (Russo et al., 2023). Then, an axial T2-weighted scan is performed at the level of the suspected disc for more detailed visualization of nerve compression or spinal canal stenosis (4). The addition of a STIR (Short Tau Inversion Recovery) sequence can help detect soft tissue edema or inflammation (Mehta et al., 2017). MRI examination of the lumbar often shows fat images that can interfere with the pathological image of the lumbar, so it is necessary to perform fat suppression techniques in suppressing fat. Some of these techniques include Fat Saturation, Short Tau Inversion Recovery (STIR), Spatial Inversion Recovery (SPIR) and the Dixon Technique (Meita Astari, 2017).

At the Radiology Department of Hospital X Semarang, in the case of HNP, there is an additional sequence, namely T2 TSE sagittal Fat Saturation. Fat Saturation is one of the techniques commonly used in MRI Lumbar examinations. This technique is part of fat suppression, which is recommended to suppress fat signals in MRI images (Hilal et al., 2013).x

Based on the description above, the authors are interested in conducting research to determine the reasons for adding the T2 TSE Sagittal Fat Saturation sequence in HNP cases.

## **LITERATURE REVIEW**

Magnetic Resonance Imaging (MRI) has become the gold standard in the evaluation of spinal pathologies, particularly herniated nucleus pulposus (HNP), due to its superior soft tissue contrast resolution and multiplanar imaging capabilities (Modic & Ross, 2007). One of the key advances in MRI technology for spine imaging is the use of fat saturation techniques, which serve to suppress the

high signal intensity of fat, thereby enhancing the visibility of pathological changes within or adjacent to fatty tissue structures (Baur et al., 2013).

Herniated nucleus pulposus refers to the displacement of the nucleus pulposus through a tear in the annulus fibrosus of the intervertebral disc. This condition is a common cause of low back pain and radiculopathy, especially in the lumbar region (Andersson, 1999). Accurate imaging is crucial for diagnosis, treatment planning, and surgical decisions. Conventional T1- and T2-weighted sequences may be limited in detecting subtle inflammatory changes or nerve root involvement due to the high signal of adjacent epidural fat (Carmody et al., 1988).

The fat saturation technique, particularly Short Tau Inversion Recovery (STIR) and fat-suppressed T2-weighted sequences, significantly improves lesion detectability by reducing the signal from fat tissue, making it easier to distinguish between normal and abnormal tissue (Zhou et al., 2004). These sequences are particularly useful for identifying nerve root edema, inflammation, and disc protrusions or extrusions compressing neural structures.

Several studies have highlighted the clinical value of fat suppression in evaluating spinal disorders. For instance, Wang et al. (2011) demonstrated that fat-saturated T2-weighted images enhanced the detection of nerve root impingement and epidural inflammation in lumbar disc herniation cases. Similarly, Ahn et al. (2000) reported improved visualization of herniated discs and adjacent neural structures with fat-suppressed MRI, leading to higher diagnostic confidence.

Despite its benefits, fat saturation techniques may be affected by field inhomogeneity, especially in areas with high susceptibility differences such as the lumbosacral spine. However, newer techniques like Dixon-based fat suppression have shown promise in providing more uniform fat signal suppression (Ma, 2008).

In conclusion, the application of fat saturation techniques in lumbar MRI plays a vital role in enhancing the diagnostic accuracy of herniated nucleus pulposus. By improving the contrast between pathologic lesions and surrounding fat, these sequences facilitate better assessment of neural structure involvement, which is crucial for appropriate clinical management.

## **METHODOLOGY**

This type of analysis uses a qualitative approach with a HNP case study. This data collection was carried out at the Radiology Department of Hospital X Semarang. Data collection in May 2024. Data analysis performed with primary data taken from three patients with HNP cases. Data were obtained by conducting observations, interviews with radiographers, and documentation. After the data was collected, a descriptive analysis was conducted based on the results of the observations and interviews. The results of this analysis were then used to make conclusions and make recommendations.

## RESEARCH RESULT

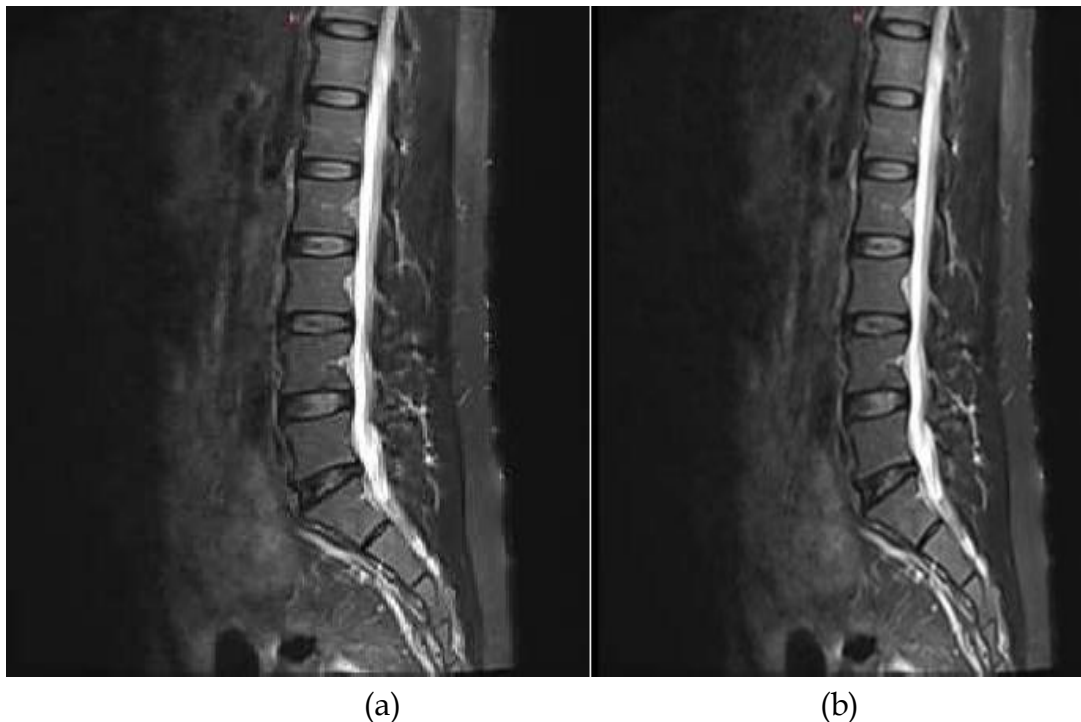
Table 1. Case Profile of Lumbar MRI Examination in HNP Cases

Category/Patient	Patient I	Patient II	Patient III
Name	Mrs. I.T	Mr. T.C	Mrs. N.S
Age	58 years old	56 years old	59 years old
Gender	Female	Male	Female
Patient History	Low back pain	Low back pain	Low back pain
Clinical Indication	HNP	HNP	HNP
Examination Request	MRI Lumbal	MRI Lumbal	MRI Lumbal

Lumbar MRI examination in HNP cases Radiology Department of Hospital X Semarang was performed without any special patient preparation. Based on the results of interviews with radiographers, there was no special preparation such as fasting because it did not use contrast media. Patients were only asked to wear patient clothes and remove objects containing metal so as not to interfere with the examination. In addition, patients were asked to urinate first considering that MRI examinations take a long time. Then the patient was given a brief explanation of the examination procedure to be carried out and the patient was instructed to be calm before, during, and after the examination so that the process runs smoothly and gets good and optimal results.

The patient's position in the MRI examination of the Lumbar in the case of HNP begins with the patient positioned supine on the examination table, hands at the side of the body. The patient is supine with the head position close to the gantry (head first). Then the radiographer fixes the patient, then the radiographer provides an emergency button and attaches earplug/headphone to the patient and a blanket for patient comfort.

The sequences used for lumbar MRI examination at the Radiology Department of Hospital X Semarang uses a routine protocol, namely localizer, T1 TSE sagittal, T2 TSE sagittal, T1 TSE axial, T2 TSE axial, and T2 SPACE FS coronal Iso Myelo. However, in the case of HNP, there is an additional sequence, namely T2 TSE sagittal Fat Saturation.



**Figure 1. (a) The Result of Sagittal T2 TSE sequence image, (b) The Result of Sagittal T2 TSE Fat Saturation sequence image.**

It can be seen in Figure 1 that in image (a), the fatty tissue appears brighter due to the absence of fat signal suppression, while in image (b), which uses the Fat Saturation technique, the fatty tissue appears darker as a result of fat signal suppression.

## **DISCUSSION**

MRI Lumbar examination in HNP cases at Radiology Department of Hospital X Semarang begins with patient preparation. Patients are asked to wear examination clothes and urinate before the examination begins. The radiographer ensures that the patient is not wearing objects containing metal and asks about the patient's history and explains to the patient and the patient's family about the examination procedure to be performed.

Preparation of patients for lumbar MRI examination in cases of hernia nucleus pulposus at Radiology Department of Hospital X Semarang is generally in accordance with the theory, which includes three important things, namely the patient is asked to urinate to empty the bladder, the radiographer explains the examination procedure, and the radiographer ensures that the patient is not wearing objects containing ferromagnetic elements (Möller & Reif, 2010).

The patient's position in the MRI examination of the Lumbar in the case of HNP begins with the patient positioned supine on the examination table, hands at the side of the body. The patient is supine with the head position close to the gantry (head first). Then the radiographer can provide knee support on the patient's knee, then the radiographer provides an emergency button and attaches earplugs/headsets to the patient and a blanket for patient comfort.

The position of the patient for the lumbar MRI examination in the case of herniated nucleus pulposus at Hospital X Semarang is generally in accordance with the theory, namely the patient is positioned lying on the examination table in the head first position, both hands beside the body, and the patient's knees are supported with knee pads (Westbrook, 2014).

The sequence used for lumbar MRI examination at the Radiology Department of Radiology Hospital X Semarang uses a routine protocol, namely localizer, T1 TSE sagittal, T2 TSE sagittal, T1 TSE axial, T2 TSE axial, and T2 SPACE FS coronal Iso Myelo. However, in the case of HNP, there is an additional sequence, namely T2 TSE sagittal Fat Saturation.

The sequences used are generally in accordance with the theory that states that the sequences used for lumbar MRI examinations are sagittal T2 TSE, sagittal PD TSE or sagittal T1 TSE, axial PD TSE or T2 GRE/TSE, coronal T2 TSE (Möller & Reif, 2010).

Based on the radiographer's explanation, it can be seen that the T2 TSE Sagittal Fat Saturation sequence in the case of Hernia Nucleus Pulposus (HNP) at the Radiology Department of Radiology Department of Hospital X Semarang was carried out to provide more optimal diagnostic information, considering that using this sequence will make the intervertebral disc more enhanced than the surrounding fat tissue. This allows for a better evaluation of abnormalities such as Hernia Nucleus Pulposus (HNP) or disc protrusion and can visualize whether there is a tear in the disc area or not so that the grade of the HNP pathology can be known. In addition, with this sequence, the nerve root is well visualized so that if there is pressure on the nerve root due to Hernia Nucleus Pulposus (HNP) it can be known.

Fat Saturation is part of fat suppression (Hilal et al., 2013). Inside the discus there is annulus fibrosus and nucleus pulposus, both components of which consist of water, collagen and proteoglycans, with the amount of proteoglycans fluid being the largest component of the nucleus pulposus. Because the largest composition is water, when the fat suppression technique is applied, the fat signal will be suppressed while the signal intensity around the pathology and discus will increase (Brandão et al., 2013). Additional fat signal suppression such as Fat Saturation is necessary to improve visualization of abnormalities in the anatomy of areas with abundant fat components such as the lumbar spine (Guerini et al., 2015).

Previous study have also shown that the use of Fat Saturation has the advantage of fast scanning time, so that Fat Saturation can be used for non-cooperative patients who need fast examination time. This is because the fast scanning time in the use of Fat Saturation can minimize the occurrence of artifacts due to patient movement (Agrilian et al., 2023)

## **CONCLUSIONS AND RECOMMENDATIONS**

Fat Saturation technique in lumbar MRI is important to increase image contrast by suppressing fat signals, so that the intervertebral disc is clearer than the surrounding tissue. Fat Saturationfat helps identify disc herniation, detect annulus fibrosus tears, and evaluate the severity of HNP. In addition, this technique allows better visualization of the nerve root, so that nerve compression

can be detected more accurately. Thus, the use of Fat Saturation in lumbar MRI plays an important role in improving imaging quality and the accuracy of HNP diagnosis.

#### **ADVANCED RESEARCH**

In addition to the Fat Saturation technique, there are several other Fat Suppression methods such as Dixon, STIR and SPAIR (that also have the potential to provide optimal image quality in MRI examinations of Herniated Nucleus Pulposus (HNP) cases. Therefore, further research is recommended to compare the effectiveness of each technique in visualizing anatomical structures and abnormalities in HNP cases. Such comparative studies are expected to provide a scientific basis for selecting the most appropriate Fat Suppression technique to support accurate diagnosis and optimal treatment planning.

#### **ACKNOWLEDGMENT**

Thank you to all parties who have helped in writing this paper.

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