How to Cite:
Radhi, H. M., Naji, N. A. R., & Zghair, M. A. (2022). Determining the image quality parameters of cervical spine diseases by using 3DT2W TSE MRI sequence for obese patients. *International Journal of Health Sciences*, *6*(S6), 1620–1628.
https://doi.org/10.53730/ijhs.v6nS6.10773

Determining the image quality parameters of cervical spine diseases by using 3DT2W TSE MRI sequence for obese patients

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***Abstract*---**Objective: The effect of obesity on MRI image quality of the cervical spine is not fully understood. The aim of this study was to examine the image quality for the degenerative diseases of obese patients by using the three-dimensional T2 weighted Turbo Spin Echo (3DT2W TSE) MRI sequence. Patients and Method: Thirty-five patients have been diagnosed with cervical spine degenerative complications. The patients were divided into two groups according to their BMI, the obese and non-obese. The MRI examinations were performed by using 3DT2W TSE sequence which was produced by a 1.5 Tesla Philips scanner MRI device to generate images for the cervical spines (C5-C6, C6-C7). The signal intensities were measured by using the region of interest (ROI) in two tissues being compared. Results: A significant difference was found in the MR image contrast between the obese and non-obese patients ($P< 0.03$) for (C5-C6, C6-C7) and the same result was found specifically with (C6-C7), where ($P< 0.04$). While the other physical measurements were not significantly differed between the two groups. Conclusion: Using of 3DT2W TSE MRI sequence is efficient for the imaging of the cervical spine's complications of the obese patients.

***Keywords*---**3DT2W, 2DT2W, obese, cervical spine.

Introduction

The prevalence of obesity is increasing all over the world. Radiology departments are facing the impact of obesity on the image quality. the hurdle in imaging obese patients is the ability to obtain good diagnostic quality images. The difficulties and solutions for imaging obese patients are specific for each imaging technique. Awareness of obesity effect on the magnetic resonant imaging (MRI) should be considered by the radiologists and technologist, studying the limitations of MRI equipment setting when imaging the obese patients need more attention to reach an optimumand MR image quality [1]. Standard, widely deployed imaging equipment is approaching its limits in the ability to image obese patients. Radiologists and technologists need to be aware of the limitations of imaging equipment and the equipment adjustments that can be made to improve image quality in obese patients. Early clinical experience with magnetic resonance imaging (MRI) has demonstrated its potential in the evaluation of the cervical spine degenerative diseases with an appropriate pulse-sequence technique.

The normal intervertebral disc is composed of a nucleus pulposus at the centre, surrounded by a fibrous ring known as the annulus fibrosis. Cervical disc herniation is a condition in which the inner gelatinous substance of the disc escapes through a tear in the outer, fibrous ring, causing a compression of the spinal cord or the surrounding nerves, resulting in neck or arm pain. A herniated disc is also a bulging disc, ruptured disc or slipped disc. A cervical herniated disc may be caused by wear and tear of the disc due to the normal ageing process or an injury to the cervical spine [2]. Magnetic Resonance Imaging (MRI) is a device used to examine and show the anatomical details of the human body. The single most important diagnostic clinical attribute of magnetic resonance imaging versus other imaging modalities is the high tissue contrast. The brightness of various tissues in the magnetic resonance image is determined by the amplitude of the radiofrequency (RF) signal pulses echoing or returning from the tissue. The selection of proper pulse sequences by the MRI technologist allows the radiologist to identify abnormal tissues and differentiate different types of normal tissues based on differences in MRI contrast [3].

In MR imaging, protons can be ‘excited’ in a thin slice only (3D) and apply magnetic gradients in three directions parallel to the plane to figure out where all the frequencies come from, creating an image of a single slice. If this is done many times, it creates a stack of slices that build a 3D volume together. This is called M3D (multiple 3D) [4]. The mathematician Joseph Fourier created the three-dimensional Fourier transformation (3DFT) that described a complicated wave in terms of simple sines and cosines. The more of them we add together, each with successively higher frequency, the better the approximation. The Fourier transform decomposes a complicated signal into its simple component waves' frequencies and relative amplitudes. These transformations are used to enhance the image of MRI. It depends on the kernel equation as a basic concept for k-space. The multiple peaks (amplitudes) in the MR frequencies represent the relative contributions of biologic metabolites in each region of interest (ROI), each differing slightly in resonance frequency because of its unique chemical structure [5]. A standard coverage of 3D k-space corresponds to the series of parallel lines

in a plane. The 2D k-space depends only on the x and y-axis of the MRI image. The 3DFT is used in the T2W sequence for 3D MRI image reconstruction [6].

3D fast spin-echo (FSE) with variable flip angle, MR imaging allows for reconstruction in multiple planes using voxels acquired isotopically with no gap. The partial volume effect is minimized, resulting in improved spatial resolution and potentially better diagnostic performance [7,8]. Measurement in 3D planes may thus allow for more accurate delineation of cervical MRI staging [9,10]. The impact of obesity on MRI represents a dichotomy, For imaging obese patients, several technical limitations need to be accounted for in MR scanning, including radiofrequency penetration and gradient strengths, limited field of view, scanning time, and radiofrequency energy deposition of the skin [10,11]. This study attempts to examine the image quality for the cervical spine degenerative diseases of the obese patients by using the 3DT2W TSE MRI sequence as well as other physical parameters that contribute to the quality of the produced image that may be affected by the increased BMI.

Patients and Method

This study involved thirty-five patients diagnosed with cervical spine degenerative complications. The patients age range was (45 to 60) years old. To study the effect of obesity on the MRI image quality, the patients were divided into two groups according to their BMI, the first group represents grade one obese patients who have a BMI of (32.251 ± 2.094) Kg/m^2 , while the second group included the non-obese patients (28.12 ± 1.1290) Kg/m^2 . The gender details of the patients is listed in table 1:

Table 1
Percentage of obese and non-obese patients according to their gender

Parameter	Male	female
Overall patients	12 (34 %)	23 (66 %)
Non- obese	5 (36%)	9 (64%)
Obese	7 (34%)	14 (66%)

The MRI examinations were performed by using 3DT2W TSE sequence which was produced by a 1.5 Tesla Philips scanner MRI device to generate images for the cervical spines (C5-C6, C6-C7). Each produced image quality was assessed by the radiologists according to determined scores (very good, good and poor) for the central stenosis, foraminal stenosis, disc degenerative herniation, bulging and Ligament flavum hypertrophy. The image quality measured parameters based on the values of the contrast, contrast to noise ratio (CNA), signal to noise ratio (SNR), the minimum signal intensity and maximum signa intensity for the obese and non-obese patients. The signal intensities were measured by using the region of interest in two tissues being compared.

Results

Table 2
The MRI parameters of 3D T2W TSE sequence in obese and non-obese patients

Parameter	Obese	Non-obese	*p* - value
Contrast	0.52 ± 0.02	0.64 ± 0.016	0.0392
contrast to noise ratio	38.32 ± 11.67	41.29 ± 11.49	0.7060
signal to noise ratio	18.29 ± 9.34	17.45 ± 6.19	0.6094
Minimum Signal Intensity	11.76 ± 1.95	6.62 ± 0.36	0.1566
Maximum Signal Intensity	190.52 ± 9.01	153.31 ± 39.01	0.1179

Table 3
The MRI parameters of 3D T2W TSE sequence in obese and non-obese patients for the cervical spines C5-C6

Parameter	Obese	Non-obese	*p* - value
Contrast	0.532 ± 0.024	0.590 ± 0.107	0.49635965
contrast to noise ratio	42.40 ± 14.54	35.969 ± 10.21	0.336192906
signal to noise ratio	18.859 ± 6.523	15.06 ± 6.78	0.292036222
Min. Signal Intensity of ROI	9.626 ± 1.045	5.42 ± 0.576	0.349085446
Max. Signal Intensity of ROI	160.874 ±29.039	149.57 ± 42.952	0.568851643

Table 4
The MRI images' subjective assessment of C5-C6 of the obese and non-obese patients. A=very good, B=good, C=poor

Parameter	Obese	Non-Obese	*p* - value
Central stenosis	A 1 (12.5 %) B 7 (87.5 %) C (0 %)	A 1 (14 %) B 6 (86 %) C (0 %)	0.1
Foraminal stenosis	A 1 (12.5 %) B 7 (87.5 %) C (0 %)	A 1 (14 %) B 6 (86 %) C (0 %)	0.1
Disc degenerative herniation, bulging	A (0 %) B 8 (100 %) C (0 %)	A (0 %) B 7 (100 %) C (0 %)	0.1
Ligament flavum hypertrophy	A (0 %) B 8 (100 %) C (0 %)	A (0 %) B 7 (100 %) C (0 %)	0.1

Table 5
The MRI parameters of 3D T2W TSE sequence in obese and non-obese patients for the cervical spines C6-C7

Parameter	Obese	Non-obese	*p* - value
Contrast	0.489 ± 0.023	0.728 ± 0.083	0.043766533
contrast to noise ratio	35.61 ± 11.39	48.74 ± 10.69	0.15446508
signal to noise ratio	19.41 ± 4.68	19.37 ± 3.28	0.994899837
Min. Signal Intensity of ROI	10.71 ± 1.98	14 ± 4.58	0.523337645
Max. Signal Intensity of ROI	184.71 ± 85.152	141.33 ± 24.090	0.252608617

Table 6
The MRI parameters of 3D T2W TSE sequence in obese and non-obese patients for the cervical spines C6-C7. A=very good, B=good, C=poor

Parameter	Obese	Non-Obese	*p* - value
Central stenosis	A 1 (11 %) B 9 (91 %) C (0 %)	A (0 %) B 3 (100 %) C (0 %)	0.01
Foraminal stenosis	A 3 (33 %) B 6 (67 %) C (0 %)	A (0 %) B 3 (100 %) C (0 %)	0.01
Disc degenerative herniation, bulging	A (0 %) B 8 (100 %) C (0 %)	A (0 %) B 3 (100 %) C (0 %)	0.1
Ligament flavum hypertrophy	A (0 %) B 8 (100 %) C (0 %)	A (0 %) B 3 (100 %) C (0 %)	0.1

The analysis of the MRI parameters of the 3D T2W TSE sequence listed in table 2 showed that there is a significant difference in the image contrast of the cervical spines (C5-C6, C6-C7) of the obese patients as compared to the non-obese group ($p< 0.05$), the image contrast of the obese patients is significantly lower than the non-obese, see images 1, 2, 3 and 4. When examining the MRI parameters of the obese and non-obese patients for the cervical spines C5-C6, no significant differences were found as shown in table 3. This result was confirmed by the subjective assessment where the statistical analysis of the listed cervical spine complications pointed to non-significant differences between the obese and non-obese patients (see table 4). While a clear significant difference was noticed in the image contrast of the obese patients when comparing it with the non-obese group for the cervical spines (C6-C7) , the image contrast of the non-obese patients was significantly higher than the obese group as shown in table 5. This was approved by the radiologists regarding the central stenosis and foraminal stenosis of (C6-C7) spines (P=0.01), where 100% of the non-obese group's MRI images were got a very good scoring of quality, while only 91% of the obese group images got the same score for the central stenosis cases. Regarding the foraminal stenosis the

radiologists' assessment showed a 100% of very good image quality for the non-obese patients, and 67% for the obese group as shown in table 6.

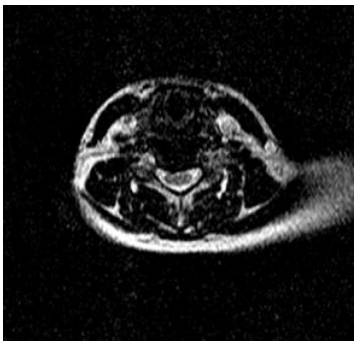

Image 1. 3D T2W TSE for C5-C6 of non- obese patients

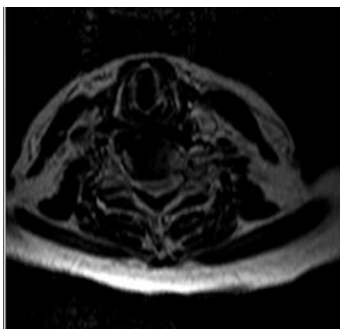

Image 2. 3D T2W TSE for C5-C6 of obese patients

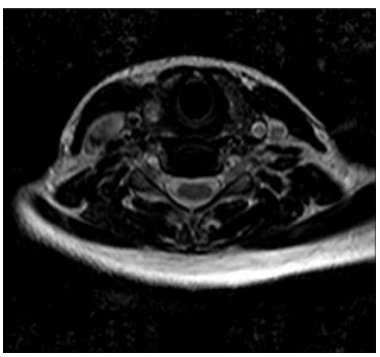

Image 3. 3D T2W TSE for C6-C7 of non- obese patients

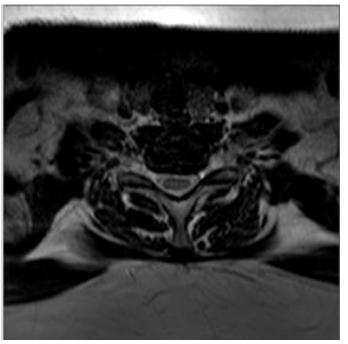

Image 4. 3D T2W TSE for C6-C7 of obese patients

Discussion

Obesity/overweight was reported to affect MR-measured signal intensity. No standard MRI imaging protocol has been established for the examination of the cervical spine of the obese subjects. physical effects of fat of obese/overweight individual may partly contribute to the changes of MR structural measures [I0,11]. The findings of the current study highlighted the significant increase of the image contrast parameter of the non-obese patients and its lower value in the obese groups espaecialy in the cervical spines (C6-C7). This contrast difference may be the cause behind the significant difference of the radiologists' assessment of the central and foraminal stenosis quality of view between the studied obese and non-obese groups. These findings can be explained by the effect of obesity on the MRI scanning times. Scanning times are increased because of the larger cross-sectional area and longer craniocaudal dimensions, which require more slices [1].

Inspite the increased MR image contrast of the non-obese patients over the obese ones, using the 3DT2W TSE was efficient in showing the (C6-C7) complications in the sagittal plane according to the subjective evaluation of the radiologists. This result is in accordance with findings of uppote et al, 2006 and Glide et al., 2021 who reported that 3D sequences allow for reformation in arbitrary planes, including perpendicular to the axis of the neural foramina (i.e. sagittal oblique) and adaptable to each level, and offer coverage of the foramina of both sides and the spinal canal in a single sequence at reasonable acquisition times [10,11]. Those authors have been used the 3D T2W SPACE sequence for imaging of the knee, lumbar, and cervical spine and have been evaluated it in comparison with conventional 2D sequences, with a focus on structure visibility and comparison to conventional sagittal and axial sequences in the cervical spine . The reasons of the found significant differences in the MR image contrast of the two groups may be related also to the selected imaging plane, where the sagittal plane was used in the current study. However, it can be difficult for technologists to determine optimal choices of imaging planes. Because 3D T2-weighted TSE imaging does not require precise planning of planes by the technologist, it can add additional information in some cases. Therefore, 3D T2-weighted TSE imaging could also potentially be useful for reducing examination time.

Conclusion

Using of 3DT2W TSE MRI sequence is efficient for the imaging of the cervical spines complications of the obese patients.

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