Analysis of BM3D Denoising Techniques to Improvement of Thoracal MRI Image: Study on Low Field MRI

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Abstract. MRI examination is one of the medical supports to assess the structure and anatomy of vertebrae thoracal. The modality that can be used is low field MRI. The disadvantages are produces low signals and noise. If the signal is low and the noise is high then the SNR value is low. The denoising technique is the right solution to remove noise. The BM3D denoising technique is able to reduce noise and increase the SNR. Aim to analyzing differences in image quality on Thoracal MRI images; study on low field MRI before and after the application of BM3D denoising techniques. This method is a quasi experimental research on Thoracal MRI images before and after the application of BM3D denoising techniques, totaling 15 samples. BM3D denoising was performed as well as assessment of Thoracal MRI images, including SNR and CNR. The Results is there are differences in SNR and CNR on Thoracal MRI images; study in low field MRI before and after the application of the BM3D denoising technique with p-value <0,001 and <0,001. The Conclusion is the BM3D denoising technique is able to improving image quality on thoracic MRI images; studies on low-field MRI.

Keywords: low field · MRI · BM3D · ***denoising***

1 Introduction

MRI is used for scanning clinical with magnetic field strength of 1.5–7 T. Nevertheless, MRI 0.2–1 T low field MRI are still used [1–3]. Low field MRI, has advantages maintenance costs low, repair devices cheaper, design buildings needed smaller such as storage space cooling system, reduce acoustic noise on neonatal and SAR value is low [1].

Low Field MRI, will have a low signal [4, 5] The big or small signal will affect the value of SNR result. Other than signal, SNR influenced by noise. If noise is high, will cause visual quality image disturbed [6]. Factors that affect SNR there are flip angle, slice thickness, TR, TE, matrix, FOV, NSA, coil used, bandwidth, and magnetic field strength [7]. Image quality on MRI influenced by SNR, CNR, Time Scanning and Spatial Resolution [8].

Noise can appear on all medical images, including on MRI [9, 10]. Noise can also appear on all types of examinations and pathologies. Noise there is one important factor

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that can lower quality medical image [11]. Denoising techniques are used to improve the quality of the image [12]. Furthermore, to remove noise from the image without remove important information on original image [12, 13].

Denoising technique assisted by Matlab (Matrix Laboratory). Matlab is a programming language that serves to solve problems the mathematically technical. Denoising techniques that has been done on MRI image using linear and nonlinear filter. Linear filter include mean and wiener filter. While non linear filter include filters median, bilateral, non local mean, and block matching & 3D [14]. Linier filter causes blurry images by pressing details, blurring the edges, removing lines and details. Therefore it is recommended to using non linear filters in image denoising [12].

According to Mehta [15] median filters have the disadvantage of eliminating detail and causing blurring of the image. Then according to More [16] bilateral filters have the disadvantage of eliminating detailed information on imagery. According to Hasan, Chaudari, and More et al. [17–19] denoising techniques BM3D succeeded in denoising image and able to improve SNR image. BM3D technique is a denoising technique sophisticated image [18, 20–23]. BM3D techniques apply 3-dimensional transformations [18, 20]. Furthermore, BM3D technique is able to admit denoising on type Poison noise, Gaussian noise, AWGN (Additive White Gaussian Noise) and Rician Noise [24–26].

Several studies have been conducted on the denoising technique BM3D, but the study used noise added not from the original noise of an MR image. Based on these reasons, in this research the application of the BM3D denoising technique on Thoracal MRI images using low field MRI.

Purpose to analyzing differences in image quality (SNR and CNR) on Thoracal MRI images; study on low field MRI before and after the application of BM3D denoising techniques.

Hypothesis there is a difference in the SNR value of the MRI Thoracal image in the low field MRI study before and after the application of the BM3D denoising technique. And there is a difference in the CNR value of the MRI Thoracal image in the low field MRI study before and after the application of the BM3D denoising technique.

In producing the desired Thoracal MRI image in the hospital, there are obstacles to be faced, namely the MRI machine used with a low magnetic field strength of 0.3 T and the resulting image contains noise. If the resulting image contains noise and the SNR value is low, then the resulting image quality is low so that doctors will have difficulty diagnosing a disease. Therefore, to overcome this problem, a denoising technique is used during image post-processing. This can help in increasing the SNR value and eliminating noise while retaining important detail and information in Thoracal MRI images without replacing the hardware on the MRI.

Several studies have been carried out on the BM3D denoising technique, but these studies use the added noise instead of the original noise resulting from an imaging scan. Based on that reason, in this study, the BM3D denoising technique was applied to Thoracal MRI images using a low field MRI machine. This research is expected to produce a more optimal image in minimizing the impact of noise from the use of low field MRI in Thoracal MRI examination.

2 Methods

This type of research is quasi experiments that use the pretest-postest two group design research design. The study was conducted on thoracal MRI image; studies on low field MRI, application of BM3D denoising technique. The samples used 15 MRI thoracal images of axial T1 FSE sequencing, with flip angle parameter 90°, slice thickness 5 mm, TR 580, TE 12, Matrix 512, FOV 220 mm, NSA 6, 35 kHz bandwidth and ETL 2. The type of sampling method is consecutive sampling. Analysis of image quality using paired t-test.

3 Results

Here is a sample image of MRI *Thoracal* study on low *field* MRI *axial* before and after the application of BM3D *denoising* techniques:

Description:

A. Thoracal MRI Image Before Denoising
B. MRI Thoracal Image with BM3D Technique

Average Signal *to Noise Ratio* (SNR) value in Thoracal MRI *image;* studies on *low field* MRI before and after the application of BM3D *denoising* techniques as shown in Table 1.

The average result of SNR values on Thoracal MRI image and average SNR values on each anatomy of Thoracal MRI image; studies on low field MRI after the application of BM3D denoising techniques according to Table 1 have the highest average value compared to before the application of denoising. This suggests that BM3D denoising techniques can improve SNR values better compared to before denoising techniques. If the SNR value increases, it can result in better MRI image quality. Analysis of different signal to noise ratio (SNR) values of the overall anatomy of Thoracal MRI image; studies on low field MRI before and after the application of BM3D and NLM denoising techniques were conducted using Anova tests due to normal distributed data. From the results in Table 1 shows that there is a difference in SNR value in MRI thoracal image

Table 1. Frequencies and Percentage of SNR Value for the Experiment Group.

Characteristic	**Before Denoising (n = 15)**	**BM3D Technique (n = 15)**	**P value**
	N	N	
Corpus	M = 12.11	M = 44.21	<0.001
Spinal Cord	M = 11.35	M = 40.18	<0.001
Proc. Spinosus	M = 15.48	M = 54.32	<0.001
Proc. Transversus	M = 15.80	M = 55.09	<0.001
Total SNR (MRI Thoracal)	M = 54.71	M = 193.80	<0.001

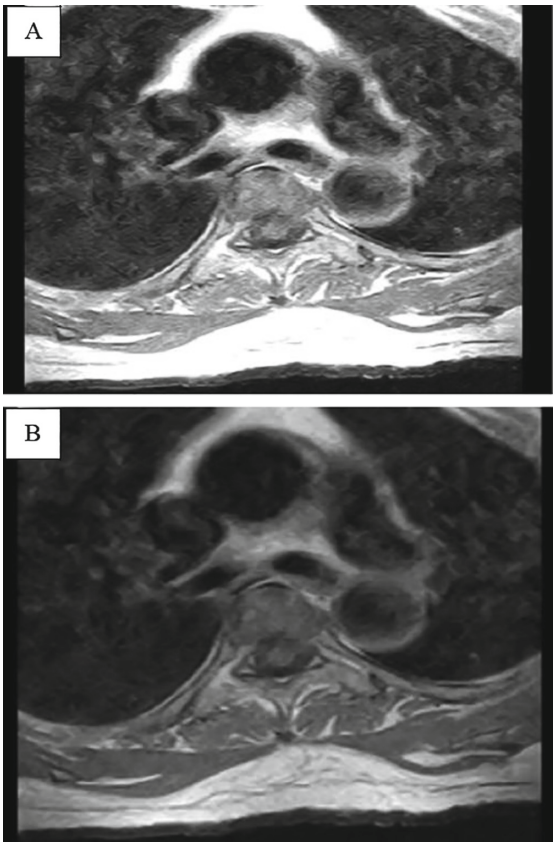

Fig. 1. MRI thoracal image before and after BM3D denoising

Table 2. Frequencies and Percentage of CNR Value for the Experiment Group

Characteristic	**Before *Denoising* (n = 15)**	**BM3D Technique (n = 15)**	**P value**
	N	N	
Corpus-Spinal Cord	M = 1.62	M = 6.83	0.006
Proc. Spinosus-Spinal Cord	M = 3.90	M = 14.14	<0.001
Proc. Transversus-Spinal Cord	M = 3.37	M = 12.33	<0.001
Proc. Spinosus-Proc. Transversus.	M = 3.17	M = 7.27	0.009
Total CNR (MRI Thoracal)	M = 12.04	M = 40.5	<0.001

study on low field MRI between before and after the application of BM3D denoising technique.

Average Contrast to Noise Ratio (CNR) value in Thoracal MRI image; studies on low field MRI before and after the application of BM3D denoising techniques as shown in Table 2.

The average CNR value in thoracal MRI image and the average CNR value of each anatomy of Thoracal MRI image; The low field MRI study after the application of BM3D denoising technique according to Table 2 had the highest average value compared to before denoising. This suggests that BM3D denoising techniques can improve CNR values better compared to NLM denoising techniques. If the CNR value increases, it can result in better MRI image quality. From the results in Table 2, showed that there is a difference in the overall CNR value of anatomy in the MRI image of thoracal study on low field MRI between before and after the application of BM3D denoising technique (Fig. 1).

4 Discussion

Judging from the SNR value generated on thoracal MRI image after the application of BM3D denoising techniques has increased. The increase in SNR value occurs because improvements have been made by eliminating noise. If the noise value decreases then the divisor factor of SNR will be small so that the SNR value will increase [27]. BM3D denoising technique performs image transformation in 3D. At that stage is the main step that is done is denoising technique on image. In BM3D denoising techniques, images are transformed in 2D first, ie. grouping the same patches and increasing the sparsity of data in the transformation domain. This is done so that the difference between the signal coefficient and noise will be more visible, making it easier in the process of identifying data that has noise [28]. Therefore, BM3D denoising techniques have better capabilities in denoising noise in thoracal MRI image; studies on low field MRI.

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5 Conclusion

Based on the results and discussions in this study, it can be concluded that there are differences in SNR and CNR on Thoracal MRI Image before and after the application of BM3D denoising technique. BM3D denoising technique able to improving image quality on thoracal MRI Image; study on low field MRI.

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