Application of intensity transfer function (ITF) on MRI ektremity with soft tissue tumor to improve image quality

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Abstract. MRI examination of extremities with soft tissue tumors are constrained in insufficient coils with enlarged objects. Recently the solution used with a larger coil such as the abdominal coil. The use of inappropriate coils will have an impact on the deterioration of image quality. The way to improve image quality is to increase Number of Excitation (NEX), but it will increase scan time and have an impact on patient comfort. Patients who are uncomfortable during the examination will make movements that can cause artifacts. Intensity Transfer Function (ITF) is carried out to help improve image quality without increasing NEX. The purpose was to improve the image quality of Signal to Noise Ratio (SNR) and Contrast to Noise Ratio (CNR). This research is a quasi experimental with a Pre Post Test Only Group Design. MRI image of the extremity obtained with the specified inclusion criteria and then the ITF is implemented. Data were analyzed by statistical tests Paired T Test. The results of the application of ITF on MRI Extremities can improve the SNR with p-value <0.001, and CNR with p-value <0.047.

1. Introduction

Magnetic Resonance Imaging (MRI) is a medical imaging technique that uses magnetic and radio frequency fields to visualize and analyze body tissues, blood flow, and metabolic functions. In its application, a magnetic field is used with a magnitude of 0.064 Tesla - 3 Tesla [1]. In an MRI examination, the object will be installed with a coil that aims to transmit and receive signals. To get a good image quality on the Radiofrequency (RF) coil, the coil is designed according to the examination with various types of sizes so that it can be adjusted to the part of the body being examined. There is a coil as a transmitter (body coil) and as a receiver (local coil), but there are also those that function as transmitters and receivers of RF signals [2]. MRI is particularly suitable for the evaluation of soft tissue tumors and tumor-like lesions because of its intrinsically high soft tissue contrast and its ability to aid in imaging superficial and deep soft tissue in large and small fields of view [3,4].

Tumors are a heterogeneous group of tumors which mostly arise from the mesoderm of daughters [1]. STT usually arises from the mesenchyme, which during development differentiates into fat, skeletal muscle, peripheral nerves, blood vessels, and fibrous tissue. STT are histologically classified based on the soft tissue components that comprise the lesion, but this does not imply that the tumor arose from these tissues. For example, a lipoma contains cells that produce fat. However, lipomas do not have to arise from fat cells [5].

In clinical STT in the extremities, the object will enlarge so that the coil that is usually used on the limb does not match the size of the object. If this is forced to continue to carry out MRI examinations
using a coil that is in accordance with the object, it will result in the clip / coil hook not being installed properly so that the RF signal is not received or re-emitted and can disturb the patient's comfort because the patient's skin surface is attached directly to the coil which will cause a burning sensation to burn [6]. Based on observations in several hospitals, to overcome this problem is to use an abdominal coil which has a size larger than the extremity coil so that the examination can still be carried out. However, the use of an abdominal coil (surface) will certainly affect the image resolution resulting in decreased intensity.

In image acquisition with MRI modality, low intensity images are often produced under certain conditions. This can be a problem that the information obtained based on the image becomes inaccurate. For example, when segmenting a certain organ in the image, the low intensity results in the boundaries between objects in the image becoming less clear. As a result, the segmented organ becomes inaccurate. In general, the visible tumor margins are only partially visible or not clearly visible on the images obtained with any sequences indicating that tumor cells have infiltrated the surrounding tissue and exhibit invasive and aggressive tumor properties.

The first step in image processing is to increase the intensity of the image so that a more detailed image is obtained, the difference in gray levels between objects [7]. How to improve the SNR can be done by using a coil size that is in accordance with the object size and positioning the coil correctly, applying a Spin Echo pulse sequence, not using a TR which is too short and a TE that is too long, using a matrix. rough, using a large FOV, choosing a thick slice, using a lot of NEX [6]. An increase in NEX will significantly increase SNR, compared to lengthening TR and shortening TE. But the consequence is that increasing NEX will increase the scan time. Increasing the scan time will increase the likelihood of patient movement [6].

Signal intensity can be improved by using the Matlab program with the ITF technique because it can perform linear transformations of the gray level and resolution of an image. The easiest way to obtain the optimal gray value range to be displayed is to perform a linear transformation of the gray value from the maximum gray value and the minimum gray value to match the data range of the pixels to be displayed [8]. When shifting the gray value of an image it can affect the brightness and contrast of the image. To visualize the relationship between the gray values in the original image and the modified image use the ITF or the intensity transfer function which is just a curve conveying the grayscale range. Basically the ITF only changes from one gray scale range to another gray scale range [8]. The purpose of this study to improve the image quality of SNR and CNR.

2. Methods

This type of research is a quasi experiment with the design of the Pre Post Test only Group Design. This design is a research design that contains pre test before being given treatment and post test after being given treatment. Thus it can be known to be more accurate because it can compare between before and after being treated [10]. By using this design, the researcher wants to know that the use of ITF for images can increase SNR and CNR. The research was conducted at the Radiology Unit of Dr. Moewardi Surakarta using GE Signa™ 1,5 Tesla. The sequence used in this research was Proton Density Fat Saturation sequence. This study used 15 patient with extremity soft tissue tumor. The sample used 15 MRI images from 15 patient of the extremities with different location of STT such as antebrachii., cruris, femur and shoulder joint. MRI image of the extremity proceed on Matlab using the ITF technique. The ITF technique used to improve SNR and CNR. The following is the formula for finding the SNR and CNR value:

\[ \text{SNR} = \frac{\text{Signal}}{\text{Noise}} \quad (1) \]

\[ \text{CNR} = \frac{\text{Signal}_1 - \text{Signal}_2}{\text{Noise}} \quad (2) \]
The result of the image was analyzing by SPSS with Paired T Test.

3. Result and discussion
In the image below is a clinical MRI image of the soft tissue tumor extremity with the Proton Density Fat Saturation sequence with ITF technique administration.

**Figure 1.** The arrows indicate that will be in the ROI

**Figure 2.** Results of MRI images of antebrachi with soft tissue tumor before (A) and after the application of ITF to the coronal slices of Proton Density Fat Saturation (B).

**Figure 3.** The results of MRI crucis images with soft tissue tumor before (A) and after the application of ITF to the coronal slices of the Proton Density Fat Saturation sequence (B).

**Figure 4.** MRI images of the femur with soft tissue tumor before (A) and after the application of ITF to the coronal slices of Proton Density Fat Saturation sequences (B).

**Figure 5.** MRI image results of the shoulder with soft tissue tumor before (A) and after the application of ITF to the coronal slices of the Proton Density Fat Saturation sequence (B).
3.1. Results of Signal to Noise Ratio (SNR) Difference Analysis before and after the application of Intensity Transfer Function (ITF) on Extremity MRI Image with Clinical Soft Tissue Tumor.

Assessment of Signal to Noise Ratio (SNR) of Extremity MRI images before and after the application of Intensity Transfer Function (ITF) was carried out quantitatively. SNR measurements were carried out in Radiant software. Data on Signal to Noise Ratio (SNR) values of MRI Extremity images before and after the application of Intensity Transfer Function (ITF) were tested for data normality. The results of test showed that the SNR data before and after the application of ITF were with a significance of 0.071 and 0.063 (p> 0.05). Thus it can be stated that the SNR data before and after the implementation of ITF is normally distributed.

Table 1. Result of Paired T Test on Signal to Noise Ratio (SNR) assessment of MRI Extremity images before and after the application of Intensity Transfer Function (ITF)

| No | Image of MRI Ekstremity | Mean SNR | Standart Deviation | Significance (p-value) | Information |
|----|--------------------------|----------|--------------------|------------------------|-------------|
| 1  | Before ITF               | 322,73   | 242,79             | < 0,001                | There is difference |
| 2  | After ITF                | 77,53    | 56,53              | 0,047                  |              |

From the results of the Paired T test in Table 1 above for the assessment of Signal to Noise Ratio (SNR) on MRI images of extremity with clinical soft tissue tumors before and after the application of ITF has a p-value of <0.001. Then it is stated that there is a difference in the SNR value on the MRI Extremity image before and after the ITF application.

SNR is the ratio of the received signal amplitude to the average amplitude of noise. The signal is received from the receiving coil from the precession in the NMV of the transverse plane. Several factors that can influence SNR are increasing the Number of Signal Average (NSA), decreasing the Receive Bandwidth, using the appropriate coil [9]. From the existing efforts to increase the SNR above, there are several factors that cannot be done in patients with soft tissue tumors. Increasing the NSA causes a long examination time, it is prone to motion artifacts due to patient discomfort. Lowering the Receive Bandwidth can cause chemical shift artifacts. The use of a suitable coil cannot be carried out in patients with soft tissue tumors because the object is enlarged so that the appropriate coil is not sufficient and using the abdominal coil as a solution applied in the hospital.

Intensity Transfer Function (ITF) is a solution to improve SNR without making patients feel uncomfortable or adding artifacts to the image. ITF works on the principle of increasing the intensity of the MRI image which is caused by a decrease in the signal. This drop in signal is caused by using an unsuitable coil.

3.2. Results of Analysis of Differences in Contrast to Noise Ratio (CNR) before and after the application of Intensity Transfer Function (ITF) on Extremity MRI Image with Clinical Soft Tissue Tumor.

The paired t test aims to compare the difference between two paired samples. The following are the results of the paired t test:

Table 2. Results of Paired T Test on the assessment of Contrast to Noise Ratio (CNR) of Extremity MRI images before and after the application of Intensity Transfer Function (ITF).

| No  | Image of MRI Ekstremity | Mean    | Standart Deviation | Significance (p-value) | Information |
|-----|--------------------------|---------|--------------------|------------------------|-------------|
| 1   | Before ITF               | -24,26  | 119,86             | 0,047                  |              |
From the results of the Paired T test in Table 2 above for the assessment of Contrast to Noise Ratio (CNR) on MRI images of extremity with clinical soft tissue tumors before and after the application of ITF has a p-value of 0.047. Then it is stated that there is not significantly difference in CNR value on the MRI Extremity image before and after the application of ITF.

Contrast to Noise Ratio (CNR) is the difference in SNR between adjacent organs. A good CNR can show the difference between a pathological area and a healthy area. It can be proven that when there is a SNR change in the image it can show a change in CNR as well.

4. Conclusions and suggestions
The conclusion of this research is the application of Intensity Transfer Function (ITF) on MRI images of clinical limb soft tissue tumors can improve the Signal to Noise Ratio (SNR) and Contrast to Noise Ratio (CNR) so that the image results have better SNR and CNR according to Paired T test with p value <0.001 and p = 0.047.

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