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EFFICACY OF THE PIXEL SHIFT METHOD IN MEASURING THE SIGNAL-TO-NOISE RATIO OF MRI IMAGES

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ABSTRACT

Purpose: The subtraction method is highly accurate for measuring the SNR in MRI, and it is frequently used for this reason. However, in clinical settings, this technique is not used very frequently due to its requirement of obtaining the same image twice. The pixel shift method was reported, which we believe can overcome this issue adequately. The pixel shift method can be used to calculate the SNR with just one round of imaging, but the effect of the number of pixels involved in the pixel shift and its direction have not yet been investigated. **Materials & Methods:** The cephalic images of the participants and phantom images were obtained for the number of different additions. Differential images of the various pixel shift and their directions were created for each image and were considered for the optimal pixel shift method by comparison with the theoretical value of the number of additions. **Results** In the pixel shift method, the edge of the structure was emphasized in a differential image. The noise was overestimated for the ROI setting,including at the edge of the structure. However, we calculated the SNR with high precision, despite using a theoretical value for comparison without depending on the number of pixels involved in the shift or its direction, when we set the ROI at the position without any surrounding structures or tissues. **Conclusion:** We estimated the position of the ROI where there are no surrounding structures or tissue, and we assessed the effect of the number of pixels involved in the pixel shift and its direction on the efficacy of the method forthe pixel shift method.

KEYWORDS: Signal-to noise ratio, the pixel shift method.

1. INTRODUCTION

The signal-to-noise ratio (SNR) is used frequently to evaluate images obtained from magnetic resonance imaging (MRI).[1] The SNR measures the quality of signal compared to that of noise, and it provides an overall estimate of the quality of the image. The subtraction method is often used to evaluate the SNR of phantom images; it involves measuring the noise of the subtracted net image of two images.[2,3] However, it is not used in cases where the scan cannot be acquired twice for the subtraction step due to ethical reasons.

In recent years, the pixel shift method has been reported, which potentially overcomes this hurdle.[4] The pixel shift method is a technique used to calculate the standard deviation from the subtraction image of an original image and the image that shifted several pixels from the original image.[5] This method is more useful for the evaluation of the clinical image compared to the subtraction method, which requires the image to be acquired twice for a subtraction step, because it requires just one image forevaluation.

However, clear criteria have not yet been defined regarding the number of pixels, direction of the pixel shift, and the region of interest (ROI) for optimal evaluation. Therefore, these dependences were considered, andmeasurement accuracy was tested.

2. MATERIAL AND METHODS

2-1. MRI acquisition and imaging parameters

A 1.5T Philips Ingenia scanner and a 16-channel head array coil was used to acquire all the images in this study. Fast spin echo was used, and the imaging parameters were set as follows: field of view, 220 mm; repetitiontime , 1000 ms; echo time , 25 ms; slice thickness, 5 mm; echo train length, 5; number of additions, 1, 2, 3, 4, 5, and 6.

2-2. Participants and Ethical Approval

Eight men and women (age: 20-22 years) were included in this study.

The phantom (model 90–401 type, by Nikko Fiennes Co., Ltd.) was used for performance evaluation. The sections were used for the evaluation of image uniformity and image distortion.

We obtained approval from the Institutional Ethical Review Board prior to conducting this study.

2-3. Image Analysis

The signal values for the mr images were calculated using image-j (v.1.80_112, national institute of health, bethesda, maryland, usa), and the subsequent analysis was carried out. For each pieceof image, the image that shifted a pixel was created from the original image using image-j. The image was shifted by one pixel, and the former image was subtracted from it (figure 1). Then, the roi was set on the subtraction image, and the standard deviation (sd) was measured. During the measurement of the snr, the roi size of the phantom image were of two kinds, and it was approximately 75% (whole roi, figure 1.3) of the size of the phantom image. The partial roi was not associated with an object or a tissue (figure 2.4).

The same ROI was set for the original image, and a mean signal value (M) was measured, and the SNR was calculated using thefollowing expression:

$SNR=\sqrt{2}\times M/SD$ (1)

2-4. Dependence of the ROI setting

The image, which was used to set the size of the ROI of the whole phantom image, created from the subtraction of the pin image and pixel shifted image is shown in Figure 1. The image with a partial ROI of a diameter corresponding to 5 mm in the area that avoided the constitution department of the manikin is shown in Figure 2.

Additionally, the square root SNR value was calculated as a theoretical value, depending on the number of additions.

We determined the precision of the actual value by comparing the value of the SNR, which we measured using a theoretical valueof the SNR as a reference.

2-5. Dependence of the direction and the number of pixels

The image that had shifted 0–2 pixels in the x, y, and xy directions, respectively, was used, and its SNR was measured.

The precision of the actual value was determined by comparing the actual and theoretical values of the SNR.

RESULTS

3-1. Dependence of the ROI setting

The results of the measurement of the SNR in a partial ROI set at an ROI size corresponding to 75% of size of the phantom image,are shown in Figure 5.

The correlation of SNR in each ROI and theoretical value is shown in Figure 6. In 75% ROI, the actual SNR value did not change witha change in the theoretical value, but the partial ROI itself showed a correlation with the theoretical value.

3-2. Dependence of the direction and the number of pixels

The SNR values measured using the image shifted 0–2 pixels in the x, y, and xy directions, are shown in Figure 7.

The change in the SNR was less for a particular direction and number of pixels involved in the shift. The correlation of the direction and number of pixels with the theoretical value of the SNR are shown in Figure 8. A method to shift to XY was the highest in terms of correlation with the theoretical value, but no difference was observed in the number of pixels involved in the shift.

DISCUSSION

In clinical settings, the timely evaluation of the image (particularly the SNR) is often required to assess a new imaging sequence and the change of the imaging condition. However, this is difficult to achieve as two images of the same slice are necessary for the subtraction method, and this is not permitted due to ethical reasons. Moreover, it is very difficult to obtain two images of the same slice via breathing phases. Therefore, in the evaluation of the SNR of the image, the use of air noise methods.[6] has been reported. In recent years, however, these assays have been effectively replaced with the spread of parallel imaging,[7] and the pixel shift method has been reported to be effective; it involves shifting one piece of an image by one pixel and measuring the noise from an image in the back for subtraction.[5]

However, so far, there have been no reports on the effect of the direction and number of pixels involved in the accuracy of evaluation, and studies have not clearly defined the optimal ROI setting either.

Therefore, we sought to assess the precision of the actual value of the SNR by comparing the measured value of the SNR with atheoretical value of the SNR.

The SNR was not found to be dependent on the direction or number of pixels involved in the shift; however, we found the optimal position of the ROI to be a location with no surrounding structures or tissue.

CONCLUSIONS

The pixel shift method was easy to perform for SNR measurement, and it was able to accurately measure the SNR. The measured ROI was located in such a manner that it avoided surrounding structures and tissues as much as possible, and it was associated with a high measurement accuracy.

Benefit reciprocity

There is no benefit reciprocity that needs to be disclosed by the lead author and collaborators.

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Figure Legends

Fig. 1: Setting of 75% ROI in the uniformity phantom (pin phantom).

Fig. 2: Setting of partial ROI in the uniformity phantom (pin phantom).

Fig. 3: Setting of 75% ROI in the human brain.

Fig. 4: Setting of partial ROI in the human brain.

Fig. 5: Results of SNR in 75% ROI and partial ROI. The SNR of partial ROI showed a high value in the whole brain compared withthat in 75% ROI.

Fig. 6: Correlation of the actual and theoretical values of the SNR for the 75% ROI and partial ROI.

Fig. 7: The SNR values of different directions and the number of pixels involved in the shift. The SNR did not depend on a directionor the number of pixels.

Fig. 8: Correlation of actual values and theoretical values of the SNR for different directions, and the number of pixels involved inthe shift. The correlation did not depend on a direction and the number of pixels involved in the shift.