A study of Wideband MR imaging: SNR and CNR

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Abstract

Most of the MR image accelerating methods suffer from degradation of acquired images, which is often correlated with the degree of acceleration. However, Wideband MRI is a novel technique that transcends such flaws. In this study we demonstrate that Wideband MRI is capable of obtaining images with identical quality as conventional MR images in terms of SNR, CNR (contrast-to-noise ratio) and image sharpness, while using only half the total scan time (Wideband factor W=2) of normal MRI sequence.

Introduction

The concept of Wideband MRI is based on the multi-carrier modulation technique in wireless communications and it increases the bandwidth in MRI. Wideband MRI simultaneously excites and acquires multiple slices using signals with multiple frequencies. RF pulses in Wideband MRI contains several bands, we define the number of bands as "Wideband multi-slice/slab factor W". It is the excitation/acquisition of this wideband signal that provides additional information necessary for acceleration. We have reported Wideband MRI acceleration technique and its potential previously [1]. Several promising applications can be realized with the help of this technique and we have demonstrated them successfully [2,3,4]. Nevertheless, image properties of the Wideband MRI technique have to be thoroughly examined in order to ensure its feasibility and validity.

Materials and methods

To compare the image quality with and without wideband MRI, two identical standard Bruker head phantoms were used. Each phantom has several structures for image quality analysis. There are 1.4mm and 1mm wide horizontal and vertical stripes specifically tailored for image resolution assessment while some cylindrical structures containing oil and porous materials can be used for contrast evaluation. All images were acquired on a 3T Bruker Biospec MR imaging system, with the use of 8826 head coil. The two phantoms were placed 14cm apart along the axial direction in the RF coil. Axial images of the two phantoms were first taken separately without using the Wideband MRI technique. Then a Wideband factor of W=2 was applied by a modified Sinc RF pulse to obtain simultaneously the images of both phantoms using half the total scan time. Imaging parameters are listed as below: FOV=19cmx19cm, total Matrix size=256x256, gradient echo sequence with TR/TE=30/6.3ms. To analyze the image, SNR signal was sampled from 9 uniform areas throughout the image and noise was calculated as the standard deviation at four corners of the image.

Results

As shown in the figures below, sets of images taken with and without the use of Wideband MRI were named as W1 and W2. Images of phantom A and B were labeled after the Wideband acceleration factor. In Fig.1, images were placed side by side to compare the details. There are no visible differences between images acquired by the conventional method (W1-A & W1-B) and W=2 wideband accelerated images (W2-A & W2-B). In the close-ups, both horizontal and vertical stripes of W1 and W2 look identical. Additionally, there are neither visible image distortions nor artifacts. The quantified SNR and contrast comparison can be found in Fig. 2. We can clearly see that W2-A has a 1.9% SNR drop while W2-B has a 4% gain. Contrast analysis also shows small difference where W2-A has 3.3% less CNR than W1-A, and W2-B has a 2% increase from W1-B. It seems that phantom A has losses in both SNR and contrast while phantom B shows the opposite. The trends in SNR and contrast of phantom A and B may be explained as the RF inhomogeneity at different locations. Nonetheless the differences can be viewed as statistical errors, indicating that Wideband accelerated images has the same image quality as normal MR images.

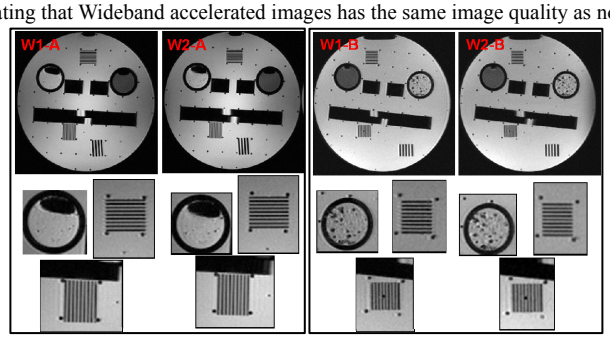

Fig. 1 Comparison between image taken without Wideband acceleration with W=2 Wideband acceleration (W2-A&W2-B)

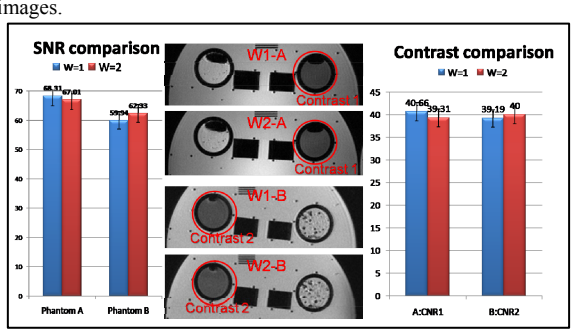

Fig.2 SNR and contrast comparison chart. Both SNR and contrast of (W1-A & W1-B) and W=2 accelerated images have negligible difference from W=1 images

Conclusion

The results strongly substantiate our claim that Wideband accelerated MR images bear no loss in image quality. We also expect the same result in other MRI sequences using Wideband acceleration. We believe it is self-evident that Wideband MRI is a powerful MRI accelerating technique that can maintain the same image quality of each accelerated image while other acceleration methods suffer from degradation such as SNR loss or artifacts. Since Wideband MRI accelerates by the increase in bandwidth instead of k-space or image space alteration, properties stated in this study can be further extended into higher Wideband accelerated images.

References

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