Simultaneous High Spatial and Temporal Resolution Imaging of the Head and Neck Using Segmented Projection Reconstruction MRI

S. Kim[1], L. Dougherty[1], M. Rosen[1], H. Song[1], J. D. Glickson[1], H. Poptani[1]
[1]Department of Radiology, University of Pennsylvania, Philadelphia, PA, United States

Introduction

Acquiring a serial MRI of the head and neck for a prolonged time, for instance 10 minutes, is a challenging task due to voluntary and/or involuntary physiological movements, such as coughing, swallowing, and respiratory motions. These movement artifacts could diminish the accuracy in the analysis of dynamic contrast enhanced images for the head and neck cancer. The projection reconstruction technique has been used to reduce the motion artifacts by sampling the low frequency components of *k*-space for every view [1]. The information gathered at the central region of *k*-space can also be used to correct for bulk motion as demonstrated with the PROPELLER MRI method [2]. However, non-rigid motions induced by coughing and swallowing can cause not only bulk motion, but also non-linear deformations of the tissue structures which are difficult to correct for. Recently, a segmented acquisition method of radial data has been introduced to provide multiple spatial and temporal resolution images simultaneously for dynamic contrast enhanced imaging of the breast [3-5]. This technique enables reconstruction of a series of independent high-temporal resolution images which can be used to monitor any movement artifact. The present study was performed to assess the feasibility of performing a prolonged scan, such as dynamic contrast enhanced imaging, of the head and neck by reducing the motion artifacts using segmented projection reconstruction MRI.

Method

The pulse sequence was developed by modifying a fast 3D gradient-echo sequence to acquire eight angle-interleaved subaperture images from full-echo radial data. The views of the second subaperture are designed to bisect those of the first subaperture. The views of the third and fourth subapertures bisect those of the first and second ones. Likewise, the views of the remaining four subapertures bisect those of the first four subapertures. All slice encoding was performed for each view angle prior to proceeding to the next view angle. This strategy provides flexibility to reconstruct images with various spatial and temporal resolutions. The data acquisition was performed on a 1.5T Siemens Sonata scanner (Siemens Medical Systems, Iselin, NJ). The imaging parameters were: 256 readout points, 256 views (32 views/subaperture, 8 subapertures), FOV = 26 cm, slice thickness = 5 mm, 8 slices, flip angle = 20˚, receiver bandwidth = 510 Hz/pixel, TR = 5.0 ms, and TE = 4.2 ms. The scan time of each acquisition was about 12 s with fat and spatial saturation. For comparison, a TurboFLASH sequence was used to scan the same slice locations with similar acquisition parameters. The experiment was performed with four healthy subjects. They were asked to either cough or swallow saliva during data acquisition. The human study was approved by the IRB, and written informed consent was obtained from all subjects prior to the scans.

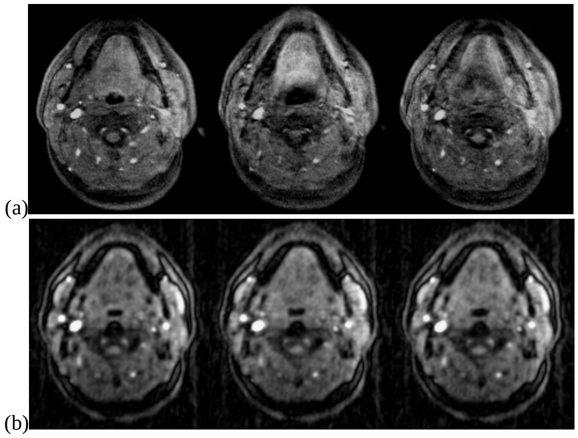

Fig.1 TurboFLASH images (a) and projection reconstruction-MRI images (b) with no motion (left), cough (middle), and swallow (right).

For the 3D dataset, slice separation was performed first by Fourier transformation along the slice direction. Projection data for each slice was regridded onto the Cartesian grid using a look-up table of coefficients calculated beforehand. Then, the final image was obtained by 2D Fourier transformation. Image reconstruction was performed for four different levels of spatial and temporal resolutions; 32 (sample points) × 32 (views), 64 × 64, 128 × 128, 256 × 256 image matrices for every 1.5, 3, 6, and 12 seconds, respectively. The lowest resolution images (highest temporal resolution) were used to detect movement by visual inspection and image correlation measure. Since coughing and swallowing cause complex tissue deformation, the contaminated image could not be restored by affine transformation. As such, those segments were eliminated to minimize the movement artifact in higher resolution images. Image reconstruction software was developed using IDL software (RSI, Boulder, CO).

Results and Discussion

Figure 1 demonstrates the robustness of the projection reconstruction method against motion artifacts due to coughing and swallowing compared with a conventional TurboFLASH sequence. Although the movements were introduced for a short period of time (< 1 s for coughing and 1~2 s for swallowing), the images acquired by the TurboFLASH sequence for 12 s were totally distorted as shown in Figure 1a. On the other hand, there is no noticeable difference between the images acquired by the projection reconstruction MRI. Inspection of the low resolution images at high temporal resolution revealed that the contamination due to either coughing or swallowing was limited to only one or two subapertures. We used the average of lowest resolution images (reconstructed from single subaperture) without motion as a reference and calculated the correlation between the reference image and each subaperture image within the ROI shown in the left panel of Fig.2. The result plotted in the right panel of Fig.2 reveals that there is one subaperture showing a noticeable difference from the reference image. This was also confirmed by visual inspection. Fig.3 shows the improvement of image quality in the images reconstructed with more than one subaperture. Fig.3a shows that there is a noticeable artifact anterior to the tongue base due to coughing (marked by arrows). This artifact was removed by eliminating the contaminated subaperture data.

These results indicate the feasibility of using projection reconstruction MRI for imaging the head and neck to minimize the effect of physiological movement artifacts. With further development, this technique might be useful for dynamic contrast enhanced imaging for head and neck cancer patients.

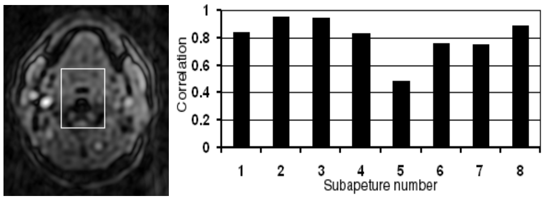

Fig.2 Left: the average of lowest resolution images without motion. Shown in the box is the ROI used to calculate the correlation. Right: Correlation between the reference image and the subaperture images with coughing.

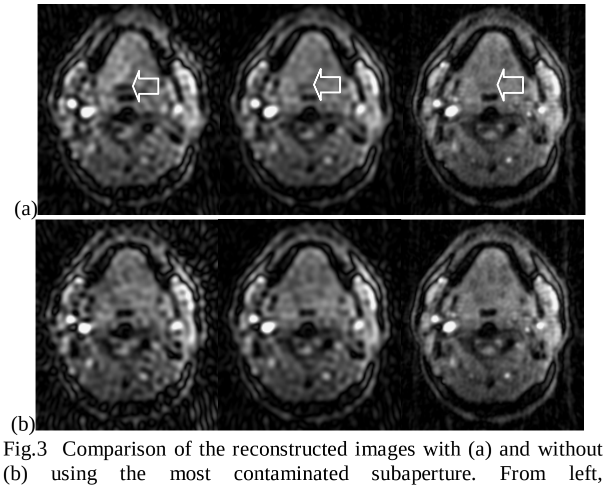

Fig.3 Comparison of the reconstructed images with (a) and without (b) using the most contaminated subaperture. From left, reconstruction matrix size of 64 × 64, 128 × 128, and 256 × 256.

References

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Acknowledgement

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