Continuous Adjustment of Calibration Values for Improved Image Quality in Continuously Moving Table Imaging

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Introduction

Previous work has demonstrated the feasibility of whole-body axial imaging at 1.5 T and 3T using a continuously moving patient table [1-4]. In the majority of these studies, the image quality was limited by the use of fixed calibration values (center frequency, transmit gain and linear shim values) over the entire body. As noted in [3] there are significant changes in the calibration values as the whole body is traversed. Here, we explore the feasibility of performing a multi location prescan and subsequently updating the calibration values in real time as the patient moves through the imaging slice. We found an improvement in general image quality when compared to using fixed values for the entire study.

Methods

Trajectory: Radial projections are acquired as the table is moved continuously. The projections are equally spaced along the z-axis with the center of rotation forming the axis of a cylinder aligned along the direction of table motion. The radial trajectory is undersampled in the kx-ky plane. As previously demonstrated, such undersampling results primarily in SNR loss, but image resolution is maintained [5]. The motion properties of radial trajectories are also superior to Cartesian acquisitions since the center of k-space is sampled during each repetition.

Acquisition: The multi location prescan method was implemented on a 1.5 T Signa TwinSpeed system (GE Medical Systems, Milwaukee, Wisconsin) with a maximum gradient strength of 40 mT/m and maximum slew rate of 150 mT/m/msec. A radial balanced SSFP (a.k.a FIESTA, True FISP, fully balanced FFE) sequence was utilized with the following parameters: TR/TE = 3.7ms/1.8ms, $\alpha=50^o$, FOV=40 cm, 256 points per readout, 128 projections per rotation, nex = 1.

Table Motion: The table velocities were calculated to ensure complete sampling before the table moved a slice thickness [3]. For this experiment the table velocity was chosen as 1.6cm/sec.

Reconstruction: An automated gridding reconstruction was implemented on the Silicon Graphics (SGI, Mountain View, California) host computer. A three-point cubic spline interpolation method was used to interpolate projections to the location of each reconstructed slice. The data was then gridded and Fourier transformed.

Volunteer experiments: Following informed consent, healthy volunteers were placed in the scanner. The imaging experiment started with an automated prescanning procedure at 16 locations spanning the entire body for obtaining the calibration values. Total time for the procedure was around 1min.The next pass consisted of performing whole body imaging with the appropriate set of calibration values updated every revolution using a linear interpolation. For comparsion, images were also acquired while maintaining fixed calibration values over the whole body. The fixed calibration values were calculated from a slice positioned at the level of mid-thigh as suggested in [1]. The shims were set to zero since they were found give better image quality than using the values obtained from mid-thigh.

Results and Discussion

Figure 1 compares abdominal images obtained while continuously changing the calibration values (1a) and those obtained while maintaining constant values (1b). All the other imaging parameters were constant. Note the banding artifacts in 1b which is not present in figure 1a. Figure 2 and 3 show images from head and thigh regions respectively with and without changing the calibration parameters continuously. As predicted, the results indicate that the general image quality improves over the whole body. The calibration parameters calculated at different body locations varied by the following amounts: center frequency ~35Hz, gradient X shim ~15%, gradient Y shim ~10%, gradient Z shim ~5%, transmitter gain ~10% (in dB). There was negligible change in the receiver gain.

Conclusion

This work shows the feasibilty of performing multi location prescan for whole body imaging and subsequently using those values during imaging. Continuously updating calibration parameters is critical to obtaining optimal image quality in continuously moving table imaging.

References

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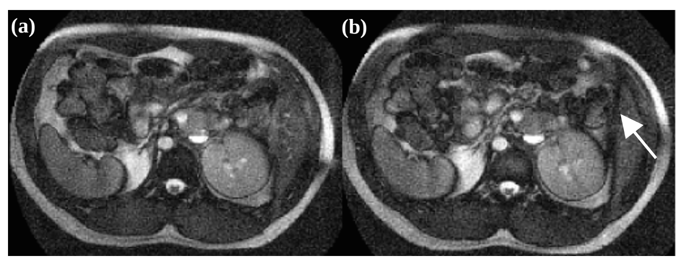

Figure 1. Abdomen images acquired with (a) continuous adjustment of calibration values and (b) with constant values applied. Note the banding artifact pointed to by the arrows in (b). This is absent in image (a).

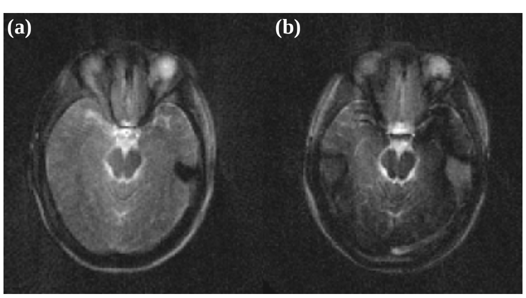

Figure 2. (a) Moving table head image with the correct calibration values updated continuously (b) with the constant calibration values applied. Note the improvement in the image quality.

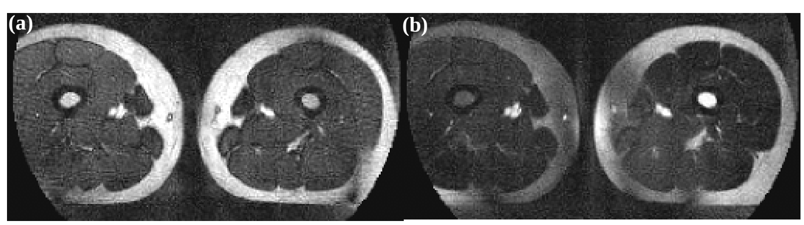

Figure 3. (a) Moving table thigh images acquired with continuous calibration value adjustment. (b) with constant calibration values applied. Note the uniform intensity across the image (a) while (b) suffers from the non-uniform intensity.