Improved coverage and fewer artifacts through oversampling in non-cartesian scans

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INTRODUCTION

As the number of available receiver coils continues to grow on MR scanners, interest in comprehensive imaging over broad field-of-views (FOVs) grows. True 3D projection reconstruction techniques have been shown to obtain a large volume with isotropic resolution rapidly. However, these techniques produce a spherical FOV, though the ideal FOV would cover a cylindrical region to match the shape of the human body. In this work, we present the benefits of utilizing a faster sampling rate to double the effective FOV without changing other acquisition parameters. The increased sampling rate is shown to also improve image quality, especially at the edges of the FOV, by reducing regridding phase errors.

MATERIALS AND METHODS

A linear increase in the data acquistion sampling rate ideally produces a linear decrease in the time necessary to sample an equivalent region of k-space. However this is true only with infinite gradient slew rates or with efficient gradient trajectories such as spirals. For oscillating gradient trajectories such as EPI or multiple echo 3DPR, faster sampling rates with higher readout gradient amplitude may make little or even a negative impact on performance. However, the faster sampling capabilities available on many platforms today may have additional benefits for non-Cartesian k-space trajectories.

Meanwhile, the minimum FOV to avoid inconsistencies between projections in 3DPR is $\sqrt{FOV_x^2 + FOV_y^2 + FOV_z^2}$. Instead of achieving faster TRs, we doubled the sampling rate without changing any other acquisition parameters to effectively double the FOV. Though the FOV is still spherical, it fully covers the cylindrical magnet bore.

The higher sampling rate also allows us to digitally demodulate each receiver coil at the center of its sensitivity region to optimize PILS [1,2]. A digital low pass filter can then be applied to limit and center accepted signal to the sensitivity region of the coil and return the image noise to its original level Then the individual coil images are reconstructed with the center of each coil image shifted to the center of the sensitivity region. The reconstructed images of multiple coils are shifted back to the original center, summed as a sum of squares for the final images.

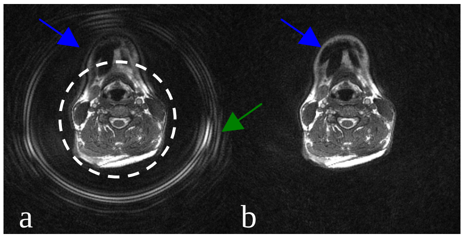

Figure 1. (a) Conventional VIPR (b) Doubled sampling rate shows improved image quality

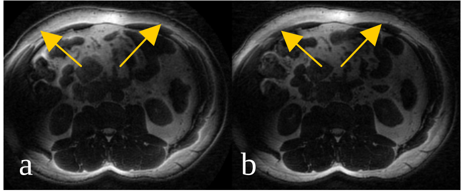

Figure 2. (a) Conventional VIPR (b) Doubled sampling rate shows improved image quality

RESULTS AND DISCUSSION

Our studies were implemented with an SSFP VIPR sequence on a GE TwinSpeed 1.5T Advantage scanner (GE Healthcare, Milwaukee, WI) with 22 mT/m peak gradient strengths and 80 mT/m/s slew rates for large FOV scans. Doubling the readout amplitude and receiver bandwidth for a 40 cm FOV with 256 resolution only reduces the TR by 10%. The FOVs for the regular head and abdominal exams were 24cm and 40 cm, respectively. The receiver bandwidths for regular acquisitions were +/-125 kHz and +/- 250 kHz for the Full FOV acquisition.

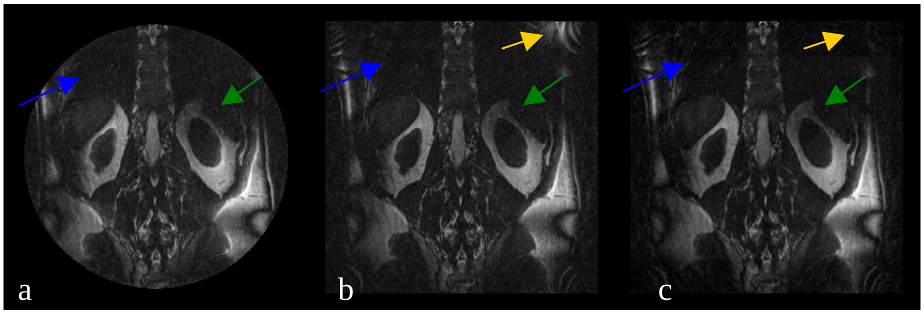

Figure 3. (a) Regular FOV **(b)Full FOV** **(c)** Full FOV with individualized demodulation frequencies per coil.

The head images near the bottom of the spherical FOV in Figure 1 demonstrate the benefits of doubling the sampling rate. Image (b) shows a wider coverage (blue arrows) and complete removal of the ring artifacts (green arrow) achieved with a Full FOV acquisition, as compared to image (b). The red circle defines the actual supported FOV we normally report. As all signal is sampled in every projection, artifacts due to inconsistencies are eliminated. The larger FOV allows the entire torso to be imaged consistently in Figure 2b. Notice the better appearance of the anterior fat wall and less ghosting of the posterior fat into the back muscles. The additional radial samples appear to reduce regridding phase errors for regions of the image away from the center where the k-space phase varies more rapidly

Figure 3 shows the further improvement gained by demodulating each coil so as to center the sensitivity region at the center of the reconstruction matrix. The yellow arrows point out the removed artifacts at the side of the body, the blue arrows show the less noisy background and green arrows shows the sharpness with doubled bandwidth.

CONCLUSIONS

Significant improvement in image quality has been achieved by simply doubling the receiver bandwidth to obtain a larger coverage without changing the scan time, and images artifacts from tissues outside of the regular FOV are removed. Further improvement in image quality is achieved by tailoring the effective FOV for each coil in a method similar to PILS.

ACKNOWLEDGEMENTS

The authors thank John Pauly for his fruitful discussions. This work was funded by the NIH R01 EB002075. We also kindly acknowledge the support of GE Healthcare.

REFERENCES

1. Griswold MA, *et al.*, MRM **343**, 1445, 2000. **2.** Lee, Pauly, Nishumura Proc. ISMRM 2003, p2351