Navigated 3D MRCP with Compressed Sensing

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Purpose

Magnetic Resonance Cholangiopancreatography (MRCP) is widely used for imaging patients with biliary disease. Typically both 2D projection breath-hold and 3D respiratory navigated or triggered imaging are obtained. 3D imaging provides improved SNR but typically has reduced in-plane resolution and is prone to reduced image quality from both respiratory and intestinal motion artefacts. The aim of this work was to evaluate the technical performance of a recently developed Navigated 3D MRCP with compressed sensing that reduces acquisition time by 50%.

Method

A respiratory navigator gated 3D MRCP acquisition was modified to perform random CS undersampling followed by a custom CS reconstruction algorithm written in MATLAB (The Mathworks, Natick, MA). The compressed sensing algorithm used a conjugate gradient solver with 15 iterations to find an image with the minimum L1 norm of its gradient for each coil.[1] The modified sequence used a combined compressed sensing and Autocalibrated Reconstruction for Cartesian (ARC[3]) sampling scheme. Randomly undersampled k-space data were processed with compressed sensing to generate aliased images for each coil. These were then Fourier transformed to give uniformly undersampled k-space data for each coil. The k-space data was then processed using ARC to generate the final image sets.

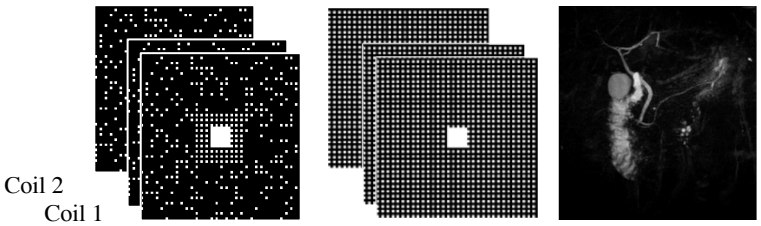

Figure 1. : Starting k-space Data (left), k-space after CS (mid) and resultant Image after ARC (right)

Following ethical approval and informed consent, 7 healthy volunteers (5 male and 2 female aged between 23 – 56 years old) were imaged at 1.5 T (MR450w, GE Healthcare, Waukesha, WI) using a 32-channel torso array coil. Volunteers were examined with both the modified and standard fast-recovery 3DFSE with extended echo train (CUBE)[4] with the following parameters: respiratory navigated gating (1R:R, 4mm acceptance window), oblique coronal orientation, ETL = 100, FOV = 320mm x 320mm, slice thickness = 1.6 mm, ARC acceleration = 2x1 and Compressed Sensing Acceleration = 2. Two in-plane resolution matrices were used to compare with the standard 3D method. a) 224 phase x256 (TEeff464-489msec) and b) 256 phase x512 (TEeff 667-696msec). The CS acceleration reduced the acquisition time on average in a) from 2 minutes 57 seconds to 1 minute 19 seconds and in b) from 3 minutes 15 seconds to 1 minute 54 seconds.

MIPS of the 3D datasets were generated with identical parameters and then compared pairwise using an Osirix Workstation (Pixmeo, Berne, CH) by two experienced radiologists in consensus, blinded to the acquisition used. Studies were first assessed for subject motion, then for diagnostic image quality using a binary scale and whether one dataset provided better diagnostic information than the other or was equivalent for the intra and extra hepatic ducts separately.

Results

In both the 224x256 and 256x512 acquisitions all studies were considered of diagnostic quality and with no significant subject motion artefacts. In the 224x256 acquisitions all 7 subject studies were rated equal for diagnostic information in both the intra and extra-hepatic bile ducts, but in the 256x512 acquisitions one case had better diagnostic information in the standard acquisition and the other 6 cases were rated equal.

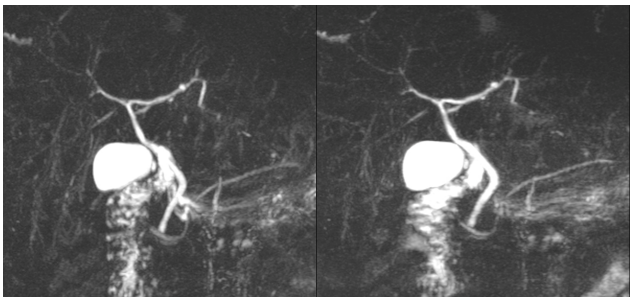

Figure 2: MIPS of (L) Routine 3D MRCP and (R) the CS accelerated version obtained in half the acquisition time

Discussion

This work indicates that CS acceleration has the potential to reduce acquisition times of 3D MRCP sequences without impairing diagnostic quality although further work is required to confirm these findings in patients with biliary disease. Future work will investigate whether 3D breath-hold acquisitions are feasible using this technique and whether overall spatial resolution can also be improved using this strategy.

Conclusion

An initial technical performance evaluation in healthy volunteers demonstrates that a CS accelerated 3D MRCP acquisition can provide similar diagnostic quality information to a standard 3D MRCP acquisition in half the acquisition time. This has the potential to reduce motion related artefacts and improve efficiency.

References

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