Accelerated high-resolution MR angiography of fingers with compressed sensing

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TARGET AUDIENCE

MR researchers in musculoskeletal angiography and in compressed sensing, radiologists, researchers and clinicians in systemic sclerosis and arthritis

PURPOSE

Angiography of fingers has been studied for the evaluation of diseases such as systemic sclerosis [1,2] and arthritis [3]. Finger angiography is challenging due to the small size of blood vessels. Compared with Doppler ultrasound, MR angiography (MRA) offers the advantage of higher spatial resolution, but it is still prone to partial volume effect. Finger MRA can be improved by using special RF coils to increase signal sensitivity to obtain higher resolution [1]. However, high-resolution finger MRA is limited in applications by long scan time and limited spatial coverage [2]. Since finger MRA data has a sparse representation with limited number of non-zero pixels for the blood vessels, it should be a good candidate for compressed sensing [4] that can be used to reduce scan time. In this preliminary study, we evaluated the utility of compressed sensing on high-resolution finger MRA.

METHODS

The study was conducted on a Siemens 3T TRIO system. A custom-built finger phased array RF coil that provided high signal and resolution was used. Axial 2D time-of-flight (TOF) images were obtained from an index finger of a normal volunteer. Imaging parameters were FOV 31mm, matrix 256x256, slice thickness 0.4mm, zero gap, 120 slices, 1 signal average, TR 21ms, TE 9.0ms and flip angle 40^0. The scan time of 10:58 mins was the minimum for the resolution and coverage used. After scanning, the raw data was transferred to a remote computer for processing. A radial Fourier undersampling scheme was applied to the fully-acquired data to simulate undersampled data sets with various rates of acceleration. Different undersampling patterns (Fig. 1) were applied to different slices. Total variation in three dimensions [5,6] was used to recover the data. The results were examined using maximum intensity display that is commonly used in clinical musculoskeletal MRA evaluation.

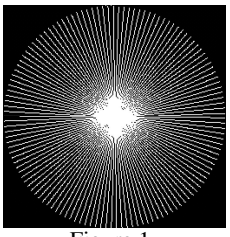

Figure 1

RESULTS

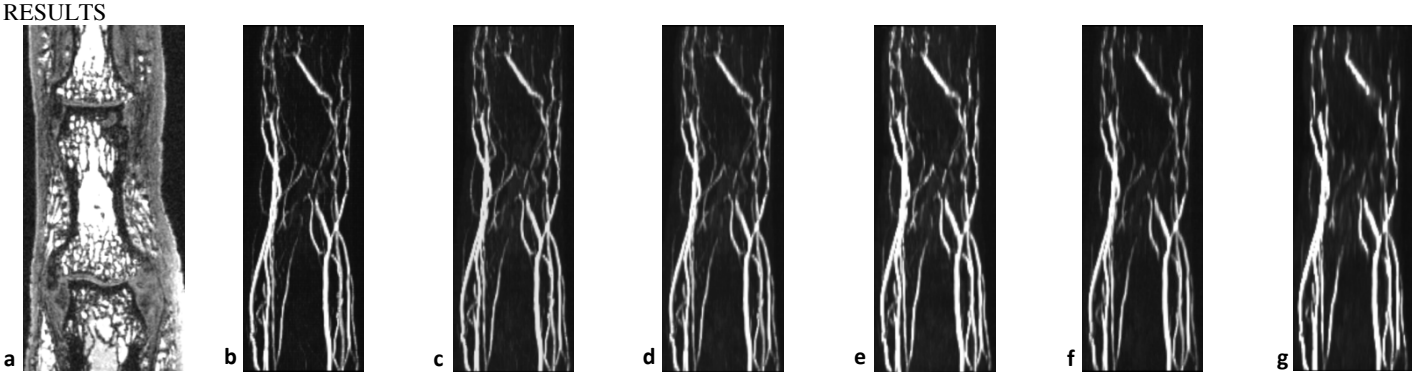

Figure 2. (a) Coronal image of the finger indicating the coverage of the MRA data, and maximum intensity display of the (b) acquired and (c-g) compressed sensing reconstructed MRA. The results show that compressed sensing data closely resemble the original data, and preserve the blood vessel information up to an acceleration of about 4. Above that rate, image blurring and loss in small vessel visualization start to affect data quality.

DISCUSSION

This study shows that compressed sensing is able to significantly reduce scan time in high-resolution MRA of fingers while preserving the blood vessel information. The in-plane and slice resolution used was much higher than those reported in other finger MRA studies [1,2]. It provided detailed depiction of vessels but required longer scan time. By reducing the scan time, compressed sensing will facilitate the clinical usage of high-resolution finger MRA. It will allow larger spatial coverage, minimize motion artifacts and improve patient comfort. This technique should also be useful for other MRA methods such as contrast-enhanced studies in fingers where short arteriovenous transit time demands short scan time [2,3]. In the future, we plan to program undersampling into the pulse sequences, and further optimize the compressed sensing technique for high-resolution finger MRA.

CONCLUSION

This preliminary study has demonstrated the feasibility of accelerated high-resolution finger MRA with compressed sensing, which should be useful for the diagnostic evaluation of diseases such as systemic sclerosis and arthritis, and should also facilitate pathogenesis studies of the diseases.

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