Highly Accelerated Real-Time Imaging of Cardiac Function Using a 32 Channel Phased Array at 3 T

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Introduction

Over the last few years, there has been an increasing trend towards 3T as a new clinical standard for many applications due to the increased SNR. At the same time, several studies have recently been performed at 1.5T which demonstrate the benefits of 32 or more receiver channels including higher SNR and faster parallel imaging [1-4]. Cardiac imaging would in particular benefit from a combination of 3T and large numbers of receiver coils. The increased SNR available at 3T allows one to significantly reduce or eliminate breathhold times using parallel imaging while still maintaining acceptable SNR. However, such large receiver systems were not clinically available until recently. The purpose of this study was to gauge the performance of a prototype 32 channel array in cardiac imaging at 3T using high parallel imaging accelerations. In particular, real-time TrueFISP acquisitions are shown at 1-dimensional acceleration factors up to 7 using the TSENSE method.

Fig. 1: Layout of individual coil elements in 32 channel array

Methods

All imaging experiments used a prototype 32 channel cardiac phased array (Rapid Biomedical). The coil array consists of 32 equivalent single coil elements which are distributed equally in a flexible anterior section and a rigid posterior section. The 16 coil elements are arranged in a 2D geometry as shown in Figure 1. Each single coil element is hexagonal with a total size of 10 cm. Each coil element has a built-in low noise high input impedance preamplifier which is located in the center of the corresponding element. All imaging experiments were done on a Siemens 3T Tim Trio with 32 independent receiver channels. Several different real-time and cine TrueFISP sequences were used in combination with the TSENSE reconstruction implemented on the scanner.

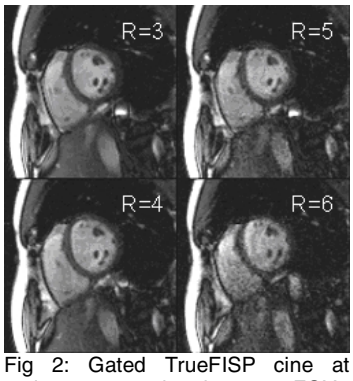

Fig 2: Gated TrueFISP cine at various accelerations. FOV= 276x340 mm, matrix 192 x 117. Slice 8 mm. 7 slices were acquired in one breath hold. The temporal resolution is 44 ms.

Results and Discussion

Fig. 2 shows a comparison of cine TrueFISP with TSENSE at acceleration factors from 3 to 6. All images show excellent image quality with no visible parallel imaging artifacts besides the expected decrease in SNR. Fig. 3 shows representative systolic and diastolic frames from a, ungated, free-breathing real time TrueFISP sequence with TSENSE accelerations of 4 and 7. In this case, the temporal resolutions were 60 ms and 35 ms respectively, demonstrating the high accelerations possible with this setup. Finally, ungated, free breathing, real-time imaging was tested at high resolution comparable to a standard clinical breathhold protocol. This is shown in Figure 4, which shows representative systolic and diastolic frames from the high resolution real-time acquisition at R=4.

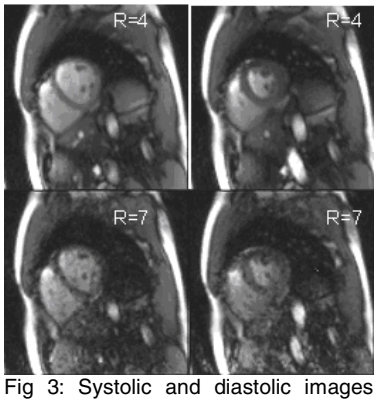

Fig 3: Systolic and diastolic images from a, ungated, free-breathing real-time TrueFISP series acquired at R=4 & 7. FOV=276x340 mm, matrix 74x128. Slice 10 mm. Temporal resolution= 60 ms (4x) or 35 ms (7x).

Conclusion

The combination of 3T and 32 channel imaging arrays has been shown to provide significant improvement in imaging speed while maintaining good image quality, even at high accelerations. Useable image quality was obtained at accelerations up to 7 for low resolution real-time scans. On the other hand, high resolution real-time images were obtained with an in-plane spatial resolution of 2.8x1.2 mm, which is similar to the typical breathhold protocol used today in the clinical routine. Therefore, we believe this technology could allow ungated, free-breathing real time imaging of cardiac function to become standard practice.

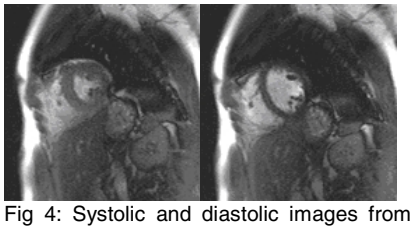

Fig 4: Systolic and diastolic images from an ungated high resolution free-breathing real-time TrueFISP series acquired at R=4. FOV=280x320 mm, matrix 100x256. Slice 10mm. Temporal resolution=92 ms per frame.

References

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