Real-Time Cardiac Imaging at 7T using a 24-Channel Cardiac Coil

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Introduction:

Cardiac magnetic resonance (CMR) commonly relies on, amongst others, a robust trigger signal. At ultrahigh field strengths (≥ 7 Tesla), ECG gating or triggering fails in a large number of cases due to magneto-hydrodynamic effects [1]. Real-time sequences with acquisition times of around 50 ms or even much shorter do not need gating or triggering. Therefore, the aim of our study was to assess the feasibility of real-time sequences at 7T for CMR.

Materials and Methods:

The CMR examinations were performed on a 7-Tesla whole-body MRI system (Magnetom 7T, Siemens Healthcare, Erlangen, Germany) equipped with a custom-built SAR supervision system. A custom-built flexible 2x4-channel transmit/receive body RF coil was used for RF signal transmission. An algorithm which optimizes the phases of all transmit channels to achieve a maximum B_1^+ in the region of interest was used for RF shimming.

For signal reception, the 8 channels of the Tx/Rx coil were used in conjunction with two additional receive coil arrays with 8 channels each. The first additional array was a dorsal array consisting of 8 square loops (105 x 105 mm^2) mounted on a Plexiglas plate (Fig. 1). The second additional array was a flexible ventral array consisting of 8 oval loops (55 mm by 95 mm) inside a soft neoprene shell, which could be closely fitted to the body contour. The neighboring elements in head-feet direction were overlapped to increase decoupling; the neighboring elements in left-right direction were not overlapped and had a spacing of 20 mm, so that the array is flexible in this direction. Both receive arrays were detuned during transmission. In all three arrays, pre-amp decoupling was used.

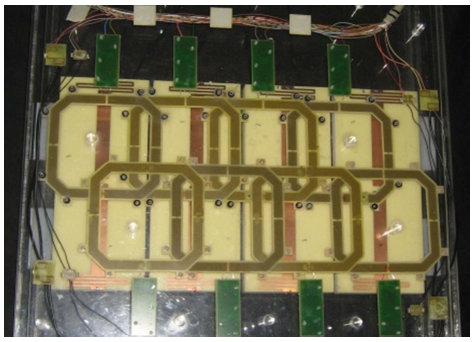

Fig. 1: Dorsal Rx array lying on top of the 4-ch meander Tx/Rx element.

After localization and B_0 and B_1 shimming, real-time imaging sequences with the following parameters were used: FLASH LiveView; TR 1.95 up to 5.8 ms / TE 1.25 up to 5.1 ms; FOV 256 x 256 mm^2; matrix 128 up to 256; radial views 15 up to 245 spokes; slice thickness 8 mm; BW 1950 Hz/pixel; flip angle 20°; duration per image 6 ms up to 106 ms. For reconstruction a sliding window approach was used.

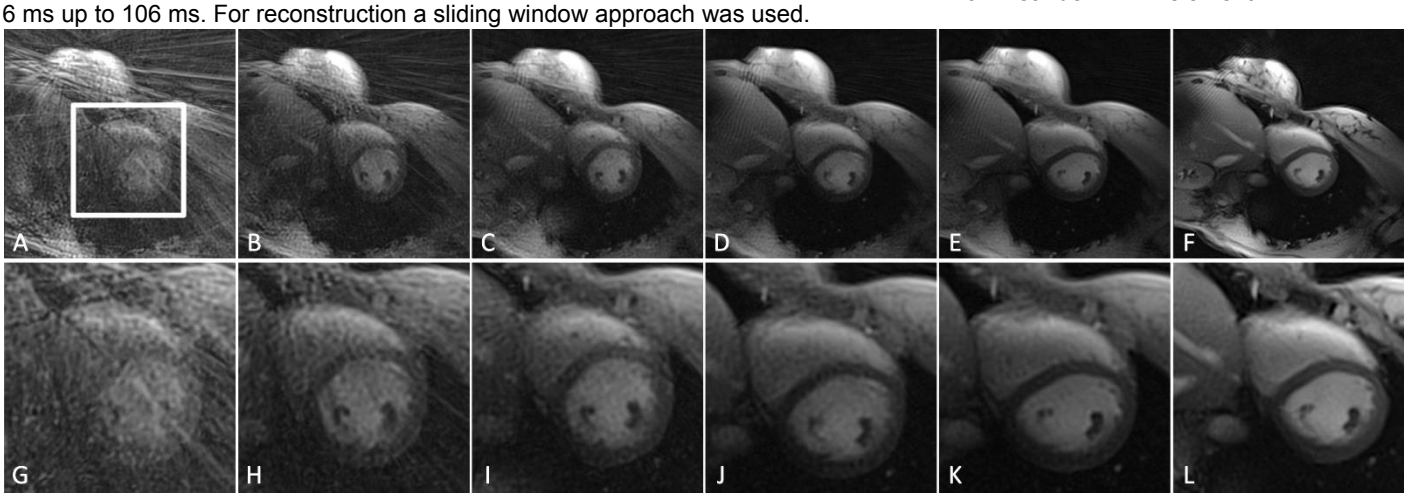

Fig. 2: Real-time short-axis images of a female volunteer with matrix 128. A-F depict the entire FOV, G-L show the same images zoomed as indicated with the white box in A. For reconstruction, 15, 30, 60, 90, 125, and 245 spokes were used, resulting in a temporal resolution of 6, 12, 24, 36, 48, and 106 ms per image respectively.

Results:

The combination of the strongly undersampled radial FLASH sequence with the Tx/Rx system on the 7T scanner enabled CMR imaging without the need for an ECG trigger. With the new 8/24ch Tx/Rx coil, acceptable image quality (without residual streaking artifacts) was achieved with the use of 125 spokes and a base resolution of 128, resulting in a temporal resolution of 49 ms (Fig. 2 E and K). RF shimming provided relatively homogeneous B_1 signal over the sensitive body volume; however, mild destructive interference associated with signal voids could be depicted in some regions of the image outside of the heart muscle. Nevertheless, the real-time sequence provided satisfactory image quality with good blood signal homogeneity over almost the entire cardiac cycle and with good myocardium-to-blood contrast.

Discussion and Conclusion:

The gridding reconstruction with a sliding window that was utilized in this study produced residual streaking artifacts when increasing the temporal resolution (by reducing the number of spokes). On the other hand, temporal blurring of the myocardium wall was visually apparent with a temporal resolution of greater than 49 ms. Reconstruction of the datasets with iterative nonlinear inversion [3] might lead to better image quality.

References:

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