Combination of Through-Plane Tissue Phase Mapping and SPAMM for 3D Cardiac Motion Assessment

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Introduction

Cardiac motion assessment can be performed by tagged imaging combined with HARP analysis and with tissue phase mapping (TPM). The tagging approach enables fast assessment of the in-plane motion component, where TPM can be applied for full assessment of the motion vector in 3D but requires at least fourfold measurement time. In this contribution it is investigated if through-plane TPM can be combined with tagging to enable three-dimensional motion assessment with halved acquisition time as compared to the full TPM approach.

Methods

The assessment of cardiac motion by the combination of TPM and Tagging was performed in 7 healthy volunteers without known cardiac disease. All imaging was performed on a 3T whole body scanner (Achieva, Philips Medical Systems, Netherlands) with a segmented gradient echo phase contrast sequence (4 k-lines per segment). The data were acquired in a conventional mid-slice short-axis view. Three scans were performed in each volunteer: One scan with through-plane TPM without Tagging, one scan with through-plane TPM and horizontal tag lines and one scan with through-plane TPM and vertical tag lines. The acquisition parameters were: TR/TE = 6.9ms/4.6ms, resolution 1.5x1.5x8mm³, flip angle 10°, VENC = 20 cm/s in through-plane direction, 18(14) heart phases for 60(80) beats per minute. To avoid flow artifacts in the TPM measurements, black-blood contrast was achieved using two alternating, presaturation pulses with 8mm distance to the imaged slice. Alternating presaturation pulses [1] were applied to reduce the SAR at 3T to enable better temporal resolution, acquiring more cardiac phases. For the evaluation of the data, the tag-lines were recognized automatically by a threshold algorithm. The through plane velocity information was calculated for all 3 velocity images: without, with horizontal and with vertical tag lines. The velocity curves were interpolated by cubic splines. The correlation coefficient between these curves was calculated.

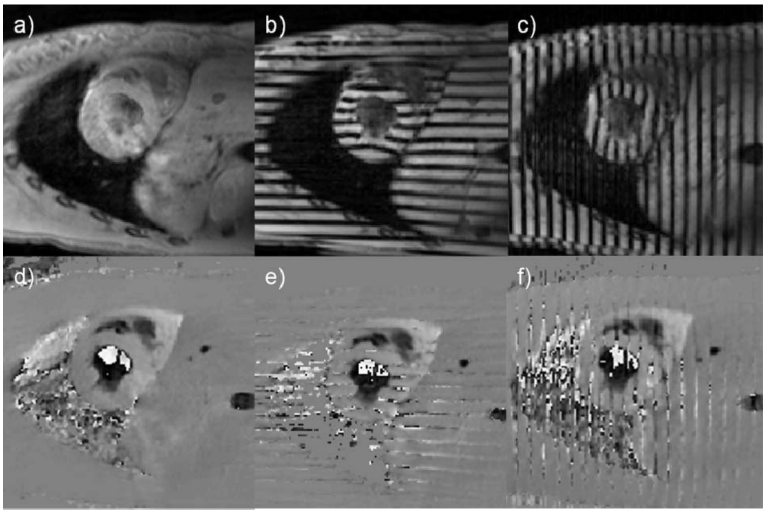

Figure 1: Anatomical (a-c) and phase contrast (d-e) images approx 180ms after the R-wave; a,d) without tag lines; b,e) with horizontal tag lines; c,f) with vertical tag lines

Results

In Figure 1 the anatomical and through plane velocity images of all 3 scans for one volunteer are shown. Due to phase wrapping, the velocity information at the position of the tag lines is disturbed. Assessed visually, the velocity information between the tag lines is similar to the motion information of the non-tagged image. Figure 2 shows the velocity profile of the through plane motion – which corresponds to the longitudinal motion of the heart – for all 3 scans in one volunteer. The profile is nearly identical. The mean correlation coefficient of the through plane motion over all volunteers between the data obtained by the horizontal tagging and without tagging results to 0.97 ± 0.01, between vertical tagging and without tagging to 0.97 ± 0.03. The correlation coefficients support the assumption, that the average longitudinal velocity curves are equivalent. The tag-lines can be detected in all cardiac phases, so that HARP analysis of the through-plane motion is possible.

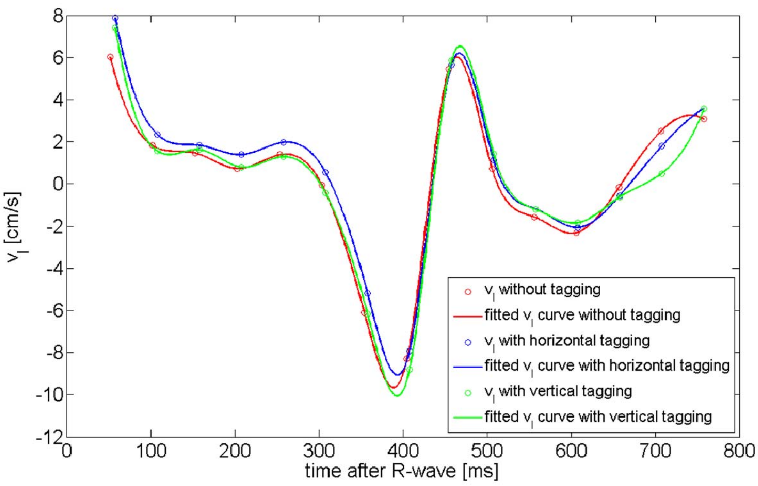

Figure 2: Longitudinal velocity measured without tagging grid (red), with horizontal tag lines (blue) and with vertical tag lines (green)

Discussion

The combination of TPM and tagging for 3D cardiac motion analysis seems feasible. There is no information loss for the evaluation of the longitudinal velocity by through plane velocity encoding, when tag lines are applied. Thus TPM combined with tagging can be used for 3D motion assessment of the heart. This is approximately 2 times faster than using 3D TPM motion encoding alone and can therefore be used, if high volume coverage is desired.

References

[1] Lutz et al., ESMRMB 2009: 489