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Direct comparison of in-vivo and post-mortem spin-echo based diffusion tensor imaging in the porcine heart

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Background

Spin-echo based cardiac diffusion tensor imaging (DTI) is highly sensitive to myocardial strain [1]. Imaging during systolic contraction requires precise planning of the sequence timing [2]. Second order motion compensated diffusion encoding has recently been proposed for small animal imaging [3] to reduce the impact of myocardial strain on the diffusion tensor.

It is the objective of the present work to compare second order motion compensated spin-echo DTI of the in-vivo and post-mortem porcine heart on a clinical MR system.

Methods

Second order motion compensated diffusion encoding gradients were incorporated into a cardiac triggered single-shot spin-echo sequence (Figure 1). A pig (55kg) was imaged on a 1.5T clinical system (Philips Healthcare, Best, The Netherlands) equipped with a gradient system delivering 80mT/m@100mT/m/ms. Eight slices (Figure 2a) were acquired during free breathing with the following parameters: resolution: 2.2×2.2mm^2, slice thickness: 6mm, reduced FOV [4]: 230×98mm^2, TR/TE: 2R-R/83ms, 10 averages. Fat suppression was established by spectral-spatial excitation. Ten diffusion-encoding directions [5] with a b-value of 450s/mm^2 were applied during early systole. The pig was euthanized by a potassium injection inside the MR scanner and the imaging protocol was repeated. Helix angle maps were calculated upon tensor reconstruction [6]. The myocardium was segmented in 4 angular and 4 radial segments per slice similar to the procedure proposed in [7] (Figure 2b).

Results

Example helix angle maps are shown in Figure 2a). Sectors were spatially matched and the corresponding correlation analysis for in-vivo vs. post-mortem data are presented in Figure 2c). Root mean squared differences between sectors in-vivo and post-mortem were 10.0°, 8.9° and 11.7° for basal, mid and apical levels, respectively. Despite significant deformation of the post-mortem heart due to the loss in blood pressure, good agreement between in-vivo and post-mortem data is revealed.

Conclusions

Good correlation between in-vivo and post-mortem imaging was found proving that bulk motion and strain effects are well suppressed if second order motion compensated diffusion gradients are employed.

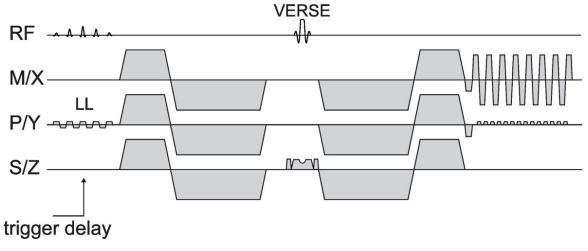

Figure 1 Sequence diagram of the second order motion compensated diffusion sequence. A spatial spectral reduced field of view (LL) excitation is used for fat suppression. A variable rate selective excitation (VERSE) echo pulse is used for refocussing.

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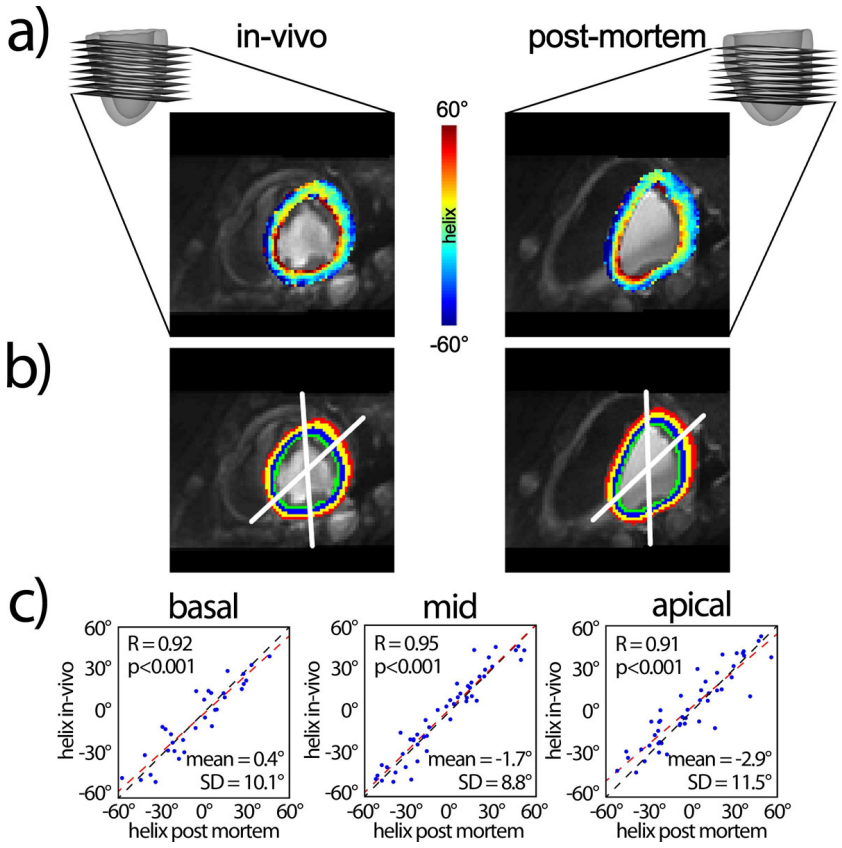

Figure 2 Slice distribution and example helix angle maps for in-vivo and post-mortem imaging are shown in a). Four angular and four radial sectors b) were identified. Mean helix angles per sector were spatially matched and correlation analysis is shown in c). The mean and one standard deviation (SD) of the differences between in-vivo and post mortem are reported.

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