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Multi-resolution simultaneous 19F/1H 3D radial imaging for self-navigated respiratory motion-corrected and quantitative imaging

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Background/objective

Fluorine MRI/MRS offers unique benefits in molecular imaging, including background-free, highly-specific detection of targeted ^{19}F-imaging agents. However, in cardiovascular applications, physiological motion compromises the quantification of sparse ^{19}F-agents and no sufficient motion information is contained in the ^{19}F-signal. Therefore, truly-simultaneous ^{19}F/^{1}H-MRI with efficient 3D-sampling is developed. It allows individual post-processing of ^{1}H and ^{19}F-data for optimized temporal, spatial resolution and SNR, needed for self-navigated, ^{1}H-based motion detection and sensitive ^{19}F-agent quantification.

Methods

Using a clinical 3 T (Achieva, Philips Healthcare) with a dual-tuned ^{19}F/^{1}H spectrometer and surface coil (transmit/receive; 7 × 12 cm) [1], isotropic 3D-radial gradient echo imaging was performed (FOV = 140 mm, matrix = 96^3, TE/TR = 2.1/6.1 ms, flip angle $\alpha_{19F}/\alpha_{1H} = 48°/12°$, 15 averages, 14 min). Robust for sub-sampling, radial acquisition was employed choosing the angle between interleaves defined as the golden-section fraction providing optimal coverage of k-space independent of sub-sample size [2]. Thus, the dynamic imaging frame rate can be chosen retrospectively to optimize temporal resolution and SNR. Furthermore, the balance between SNR and spatial resolution can be modified via k-space weighting (standard k^2-weighting within a defined radius, uniform weighting outside). Anesthetized, hyper-cholesterolemic, atherosclerotic rabbits were imaged 3 h post-injection of $\alpha_v\beta_3$-targeted perfluoro-15-crown-5-ether nanoparticles. A respiration sensor was placed on the abdomen as external reference. For respiratory motion tracking, dynamic ^{1}H images were reconstructed with a temporal resolution of 0.35 s (58 profiles/frame, 160× sub-sampling). The k-radius weighting factor was varied from 0.025-1.0 to ascertain a favorable compromise between SNR and resolution for detecting diaphragm motion. 3D translational motion information, extracted from ^{1}H data via cross-correlation within a volume-of-interest, was used to correct ^{1}H and ^{19}F image datasets. The k-radius in weighted reconstruction of ^{19}F-data was chosen independently to optimize the spatial resolution for a given concentration and SNR of the nanoparticle agent on the aorta.

Results

Isotropic 3D simultaneous ^{19}F/^{1}H images were acquired and successfully reconstructed using self-navigated respiratory motion correction (see Figure 1). For the required 0.35s temporal resolution, a k-radius of 0.10 provided optimal compromise between SNR and resolution for diaphragmatic motion detection. Motion-corrected ^{1}H images clearly demonstrated improvement, especially near the diaphragm. Improvements in the lower resolution ^{19}F images were also present (though less pronounced) and can be crucial for quantification accuracy.

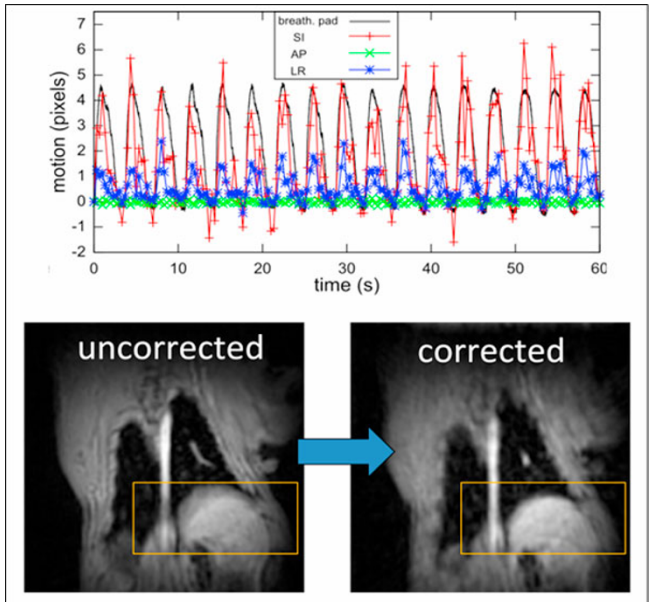

Figure 1
(Top) Comparison of external recording of respiratory motion (black line) with 3D *in vivo* motion derived from the ^{1}H component of the simulataneous ^{19}F/^{1}H imaging, Motion in the SI (+) and PR (*) directions track well, with little motion detected in AP (x) direction. (Bottom) Correcting for the motion, images and imporved, especially near the liver and diaphragm (box). Note the ghost artifact of the thoracic aorta is removed in the corrected image.

Conclusion

Sub-sampled, 3D isotropic radial imaging with golden section profile interleaving allows flexible, self-navigated 3D respiratory motion compensation based on simultaneously-acquired ^{1}H signal for multi-resolution ^{19}F imaging and quantification.

References

1. Keupp J, *et al.*: *Proc ISMRM* 2006, **14:**102.
2. Chan RW, *et al.*: *MRM* 2009, **61:**354.