Lugand et al. Journal of Cardiovascular Magnetic Resonance 2015, 17(Suppl 1):W30
http://www.jcmr-online.com/content/17/S1/W30

Journal of Cardiovascular Magnetic Resonance

WORKSHOP PRESENTATION Open Access

# Accelerated and KWIC-filtered cardiac $T_2$ mapping for improved precision: proof of principle

Emeline Lugand[1,2], Jérôme Yerly[1,2], Hélène Feliciano[1,2], Jérôme Chaptinel[1,2], Matthias Stuber[1,2], Ruud B van Heeswijk[1,2*]

*From* 18th Annual SCMR Scientific Sessions
Nice, France. 4-7 February 2015

## Background

In recent years, several successful variations of $T_2$-prepared cardiac $T_2$ mapping techniques have been described for the quantification of cardiac edema [1,2,3]. Radial imaging for high-resolution $T_2$ mapping [3] has the advantage of reduced motion sensitivity, but suffers from a lower signal-to-noise ratio (SNR) due to the undersampling of the periphery of k-space and the density compensation function (DCF) that increases the weight of the relatively noisy and less densely sampled k-space periphery (Fig.1a). Since the contrast of an image is defined by the center of k-space, a KWIC (k-space weighted image contrast [4]) filter can be used to share only the periphery among radial images that have the same geometry and different contrast, such as those used to generate a $T_2$ map (Fig.1b). Furthermore, when undersampling is used to acquire more images per $T_2$ map (resulting in more k-space peripheries that can be shared), KWIC filtering further reduces the noise-like undersampling artifacts (Fig.1c). The goal of this study was therefore to test whether the use of the KWIC filter leads to a higher precision in radial $T_2$ maps for a given acquisition time.

## Methods

Standard navigator-gated radial $T_2$ maps at 3T (Siemens Skyra) were acquired with 3 $T_2$Prep durations, 308 radial lines with golden-angle increment per image, matrix 256x256, and spatial resolution $(1.17mm)^2$[3] in an agar-$NiCl_2$ phantom with relaxation times that approximated myocardium and blood. Subsequently, $T_2$ maps at the same location were acquired with 6 $T_2$Prep durations, with 308 and 110 lines per image. $T_2$ maps were reconstructed both with and without the KWIC filter. The $T_2$ standard deviations ($\sigma_{T2}$) of the myocardial compartment in the resulting $T_2$ maps were then compared. Finally, the same protocol was applied for the myocardium in 3 healthy volunteers.

## Results

All phantom $T_2$ maps could be successfully reconstructed (Fig.2a). The KWIC-filtered and undersampled $T_2$ map was acquired in 72% of the standard acquisition time, and resulted in a $\sigma_{T2}$ decrease from 2.1 to 1.2ms (Fig.2b). The acquisitions in the volunteers were similarly successfully reconstructed, and the resulting $T_2$ values and $\sigma_{T2}$ for the KWIC-filtered $T_2$ maps (38.7±3.3ms) did not differ from the standard $T_2$ maps (37.6±3.1ms, Fig. 2c&d).

## Conclusions

The phantom study demonstrated that the application of the KWIC filter to radial $T_2$ mapping allows for a shortening of the acquisition time together with an increase in precision. The equivalency of the KWIC-filtered protocol *in vivo* might be caused by the lower overall SNR that is exacerbated by the undersampling, although this needs to be investigated in a larger cohort.

## Funding

Emma Muschamp Foundation (RBvH).

### Authors' details

[1]Radiology, University Hospital (CHUV) and University (UNIL) of Lausanne, Lausanne, Switzerland. [2]Center for BioMedical Imaging (CIBM), Lausanne, Switzerland.

[1]Radiology, University Hospital (CHUV) and University (UNIL) of Lausanne, Lausanne, Switzerland
Full list of author information is available at the end of the article

BioMed Central

© 2015 Lugand et al; licensee BioMed Central Ltd. This is an Open Access article distributed under the terms of the Creative Commons Attribution License (http://creativecommons.org/licenses/by/4.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited. The Creative Commons Public Domain Dedication waiver (http://creativecommons.org/publicdomain/zero/1.0/) applies to the data made available in this article, unless otherwise stated.

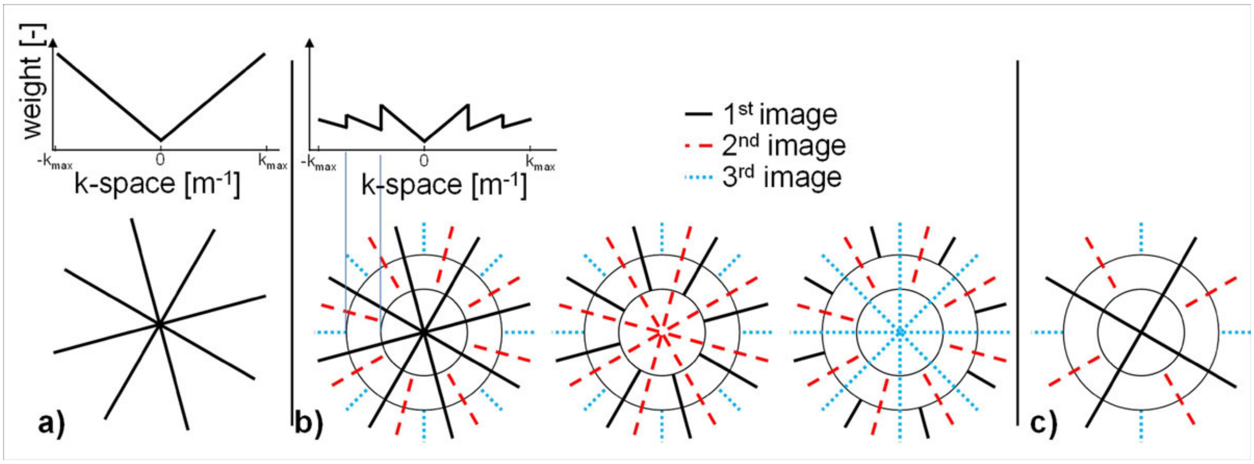


**Figure 1** Schematic overview of radial k-spaces and their DCF. a) A normal radial k-space sampling pattern with above it the DCF along one radial line, which will be used to weigh the k-space points when regridding before the Fourier transform. Because of their high density, data from the center of k-space have a much lower weight than data from the outside. b) Three similar k-spaces that share their periphery through the KWIC filter, thus increasing the local sampling density and decreasing the local DCF (which in turn prevents noise amplification). The circles (determined with the Nyquist criterion) indicate the radii outside of which an extra k-space is added. c) An undersampled KWIC-filtered k-space. While the number of lines has decreased, the periphery of k-space still has a higher sampling density.

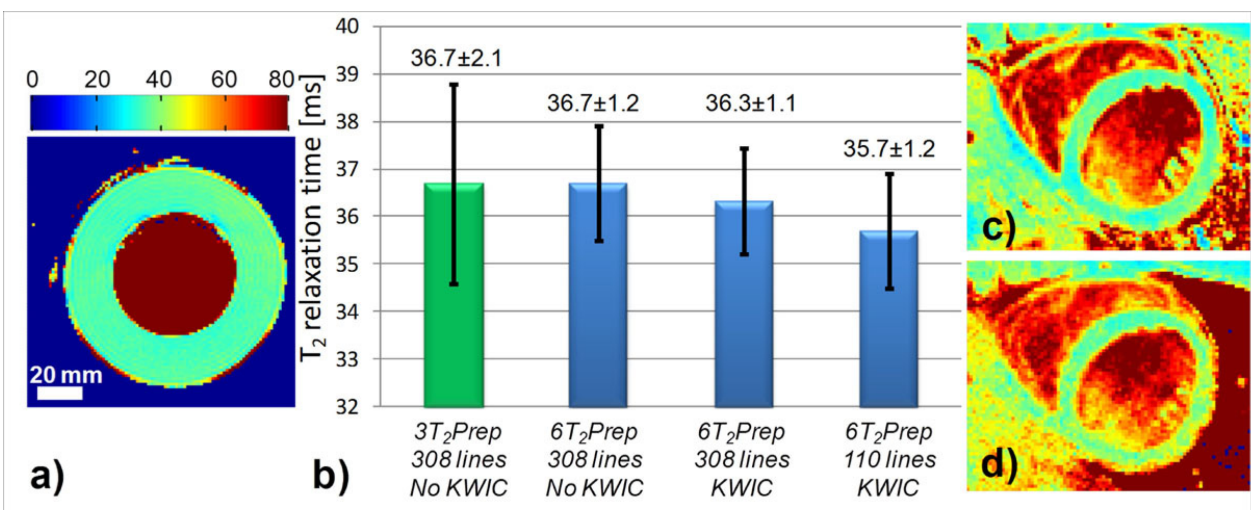


**Figure 2** Radial $T_2$ mapping with the KWIC filter. a) Example of a $T_2$ map of the phantom, with a homogeneous $T_2$ in blue-green circular compartment that has relaxation times similar to those of the myocardium. b) Results of the different $T_2$ mapping techniques in the phantoms. The KWIC-filtered image that uses ~36% of the radial lines (and thus 72% of the acquisition time) has a significantly lower $T_2$ standard deviation. c and d) Short-axis cardiac $T_2$ maps in volunteers demonstrate equivalency of the undersampled images.

Published: 3 February 2015

**References**

1. Foltz, *et al*: *MRM* 2003.
2. Giri, *et al*: *JCMR* 2009.
3. van Heeswijk, *et al*: *JACCImaging* 2012.
4. Song, *et al*: *MRM* 2000.

doi:10.1186/1532-429X-17-S1-W30
**Cite this article as:** Lugand *et al.*: **Accelerated and KWIC-filtered cardiac $T_2$ mapping for improved precision: proof of principle.** *Journal of Cardiovascular Magnetic Resonance* 2015 **17**(Suppl 1):W30.