Breath-held high-resolution cardiac T$_2$ mapping with SKRATCH

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Background
Several cardiac T$_2$ mapping techniques with varying T$_2$ preparation (T$_2$Prep) times have been proposed for the quantification of cardiac edema [1-3]. Among these, radial T$_2$ mapping, which is robust to motion artifacts, suffers from a low signal-to-noise ratio (SNR) caused by the undersampling of the k-space periphery and by its density compensation function (DCF) (Fig. 1a). However, since the contrast of an image is mainly determined by the center of its k-space, the T$_2$-weighted images can share their k-space periphery using the KWIC (K-space Weighted Image Contrast) filter (Fig. 1b) to reduce undersampling artifacts [4]. This allows for higher undersampling (Fig. 1c) and thus for a decrease in acquisition time [5].

We demonstrated that navigator-gated KWIC-filtered cardiac T$_2$ mapping (Shared K-space RAdial T$_2$ Characterization of the Heart, SKRATCH) enables a considerable decrease in acquisition time while maintaining the T$_2$ precision [5]. The goal of this study was to extend this approach to a short breath-held high-resolution T$_2$ map acquisition and to compare its performance to navigator-gated T$_2$ mapping.

![Figure 1 Schematic overview of the KWIC filter](image)

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Methods
The novel breath-held SKRATCH protocol consisted of a GRE sequence with a continuously increasing golden-angle radial acquisition. This ensured a unique k-space trajectory for all 64 lines of each of the 4 $T_2$ Prep durations (0/30/45/60 ms), pixel size of $1.2 \times 1.2 \times 8$ mm$^3$ and a total duration of 7 heartbeats. As reference, a navigator-gated radial cardiac $T_2$ mapping GRE sequence was acquired with 3 $T_2$ Prep durations (0/30/60 ms), 308 lines/image and a pixel size of $1.25 \times 1.25 \times 5$ mm$^3$ [3]. Images were acquired at 3T (Magnetom Prisma, Siemens Healthcare) in 17 healthy volunteers at the same midventricular short-axis orientation with both protocols. The $T_2$ maps were segmented according to the AHA guidelines [6]. The mean $T_2$ value ($\mu_{T_2}$) and the relative standard deviation ($\sigma_R = \text{standard deviation} / \mu_{T_2}$) of each segment as well as the myocardial area were calculated and tested for significant differences. The SKRATCH $T_2$ map was acquired twice in 11 of the volunteers for Bland-Altman reproducibility analysis.

Results
The SKRATCH $T_2$ maps had average values of $39.9 \pm 4.4$ ms, while those of the reference $T_2$ maps were $39.1 \pm 3.1$ ms ($p = 0.04$, Fig. 2a-c). $\sigma_R$ increased from $8 \pm 2\%$ for the standard $T_2$ maps to $11 \pm 2\%$ for the SKRATCH $T_2$ maps ($p < 0.001$). The myocardial area decreased from $643 \pm 155$ to $585 \pm 121$ pixels for the SKRATCH $T_2$ maps (a 10% decrease, $p = 0.008$). The repeatability analysis resulted in a confidence interval of $\pm 3.09$ ms (Fig. 2d).

Conclusions
The SKRATCH $T_2$ maps were highly similar to the reference high-resolution $T_2$ maps, while the shortening to breath-hold duration came at the cost of an acceptably small increase in standard deviation and decrease in

Figure 2 A comparison of navigator-gated and breath-held high-resolution $T_2$ maps in healthy volunteers. a,b The standard navigator-gated $T_2$ map and breath-held SKRATCH $T_2$ map respectively. Note that the maps are homogeneous and have similar myocardial surface available for analysis. The color bar indicates the $T_2$ relaxation time in ms. c The mean $T_2$ values and standard deviations of the 17 healthy volunteers show a slight increase in standard deviation for the breath-held SKRATCH acquisition. d The Bland-Altman analysis of the difference in mean $T_2$ values for 11 volunteers. The dotted line represents the mean with a bias of 0.28, while the continuous lines represent the 95% confidence interval ($1.96 \times \text{standard deviation}$).
myocardial area. These encouraging results will need to be validated in future high-resolution studies in patients.

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References
1. Foltz, et al: MRM 2003.
2. Giri, et al: JCMR 2009.
3. van Heeswijk, et al: JACC Imaging 2012.
4. Song, et al: MRM 2000.
5. Lugand, et al: ISMRM 2015, 23-P28.
6. Cerqueira, et al: Cir 2002.

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