Multi-slice TSENSE Cardiac CINE SSFP Imaging with a 32-Channel Cardiac Coil

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Synopsis:

This study evaluates the use of a 32-element array-coil for cardiac CINE imaging with acceleration factors up to 7 using the TSENSE method. TSENSE data sets from a multi-slice segmented SSFP technique were compared to nonTSENSE data with respect to contrast, image quality and volumetric accuracy. Although CNR substantially decreased for R>5 due to increasing g-factor, all data sets showed accurate volumetric evaluation. Quality ratings showed fully diagnostic data for R≤4. This data shows that high acceleration factors are useful in cardiac CINE imaging and may eliminate the need for multi breath-hold imaging by acquiring an entire stack of slices.

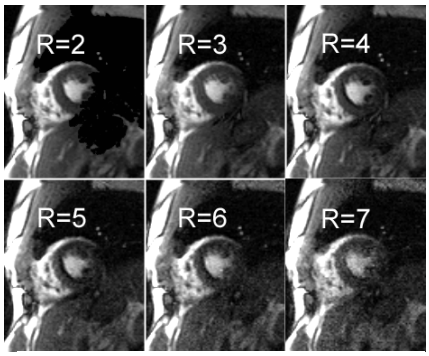

Figure 1: Comparative short axis images using R=2-7 showing increased

Introduction:

The advent of parallel imaging techniques in routine cardiac MR has led to substantial improvement of CINE imaging especially using a real-time approach [1]. However, with the acquisition of multi-slice data sets spatial resolution has been limited because most clinically used acceleration factors are only in the range of 2-3. For accurate assessment of global and regional wall motion high spatial and temporal resolution is essential [1,2]. The recent development of new generations' scanner and new coil technologies may expand the range of acceleration factors, allowing multi-slice single breath-hold imaging with adequate spatial and temporal resolution. The TSENSE method reconstructs data from sensitivity profiles acquired in a dynamic fashion by alternating the sampled k-space lines without additional loss of time [3].

The purpose of this study was to evaluate a prototype 32-element cardiac array coil for cardiac CINE imaging using TSENSE with acceleration factors up to 7. The results are compared to nonTSENSE images with respect to contrast, contrast to noise (CNR), image quality and accuracy in volumetric evaluation.

Material and Methods:

15 individuals (11 volunteers, 4 patients) underwent CINE MR imaging on a 1.5T scanner with 32 independent receiver channels (Magnetom Avanto; Siemens, Erlangen, Germany). For signal reception a prototype 32-channel cardiac phased-array coil (RAPID Biomedical, Rimpar, Germany) was used. All CINE imaging was performed in double oblique short axis orientation acquiring three slices in a single breath-hold using segmented SSFP (2/0.8/55°). In-plane resolution was 1.9x2.5mm with 48ms temporal resolution. Multiple acquisitions at varying TSENSE acceleration factors (2-7) were performed and compared to nonTSENSE data (R=1) (Fig.1). Contrast measurements were based on averaging enddiastolic and endsystolic signal at identical positions for all data sets for myocardium (MYO) and the left ventricular blood pool (BLOOD). CNR calculations were performed for nonTSENSE measurements and the according CNR of accelerated data sets was calculated as follows: $CNR_R = CNR_{nonTSENSE} \Big/ \sqrt{R} \times g$ (1)

where *R* is the acceleration factor and *g* the geometric factor of the coil that was determined from phantom measurements for different values of R (measurements to be described elsewhere). at a given acceleration factor determined in phantom measurements. As the g-factor varied over the FOV, the highest value (worst case) was used for determining CNR in Equ. 1. In addition image rating was performed by two experienced readers with respect to image noise, artifacts and overall image quality using a 4-point scale. Volumetric measurements were performed calculating an end-diastolic volume (EDV), end-systolic volume (ESV) and myocardial mass (MASS) equivalent for all acceleration factors based on the 3 slice data set using semiautomatic commercial post-processing software.

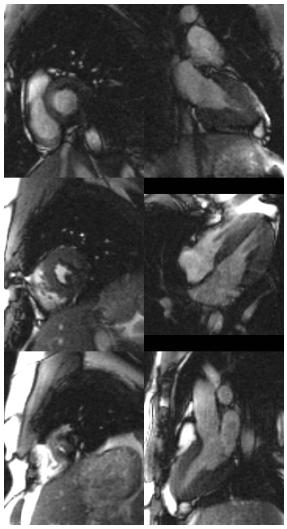

Figure 3: Multi-slice SSFP single breath-hold data set with R=4 acquired at multiple slice orientations.

Results:

TSENSE data sets up to R=4 were all (100%) rated fully diagnostic as well as the majority (83%) of data sets with R=5. With higher acceleration factors (R=6-7) the vast majority were rated to have limited diagnostic quality, although none were rated as non-diagnostic (Fig.2). Image quality for R=2 showed no significant differences to nonTSENSE (P=NS). CNR decreased significantly (R=1 62±19 vs. R=4 31±9 vs. R=7 9±3; P<.0001) with increased R while MYO/BLOOD contrast remained stable (R=1 120±42 vs. R=7 122±47; P=.46). In volumetric assessment of EDV, ESV and MASS no significant differences at R≤5 to nonTSENSE could be found (EDV: R=1 117±16 ml vs. R=5 114± 12 ml ;P=0.31).

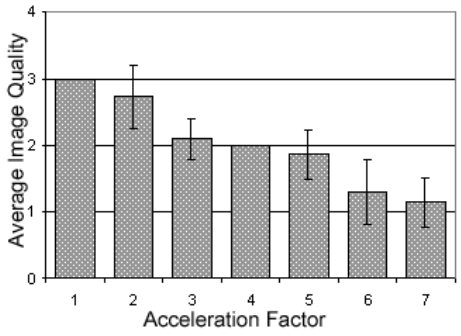

Figure 2: Average image quality rating for nonTSENSE data (R=1) and increasing R (2-7).

Discussion:

TSENSE cardiac CINE SSFP imaging using a new 32-channel phased array coil allows for increased acceleration factors and the acquisition of multiple slices (up to 6) within a single-breath-hold at high spatial resolution (~ 20s at R=4)(Fig.3). In this study, we limited the number of slices to 3 in order to collect non-accelerated data in a reasonable breath-hold. Besides the increase in noise, resulting from shortened acquisition time, there was also pronounced loss in CNR from increasing g-factors for R>4. However, quantitative evaluation of global function was possible at higher acceleration without increased post-processing time. The presented data shows the ability of this technique to eliminate the need for multi breath-hold imaging of cardiac function. Further improvement in acquisition SNR performance is expected with 3D methods that utilize two dimensional accelerations [4].

References:

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