**Real-time imaging of speech production using radial *k-t* SENSE**

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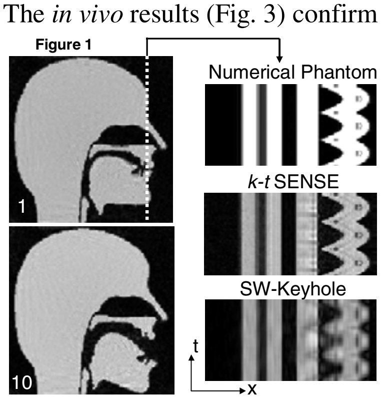
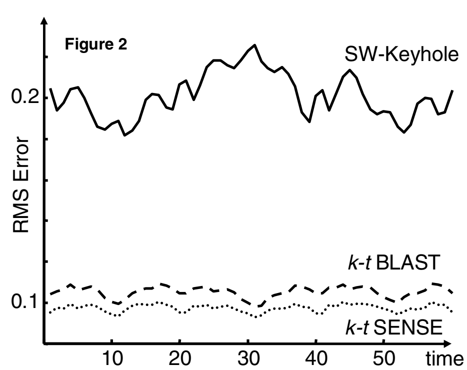
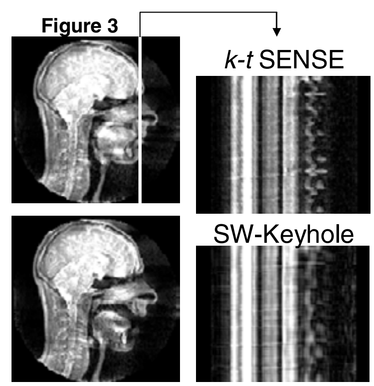
**Introduction.** The *k-t* BLAST and *k-t* SENSE techniques exploit spatial-temporal data correlation to accelerate dynamic MRI [1]. Specifically, since it is possible to represent the dynamic dataset with fewer degrees of freedom, it is possible to reconstruct from fewer acquired data points. The techniques have primarily been used with sampling patterns that conform to a lattice in *k-t* space, but recently it has also been demonstrated that the coil-by-coil *k-t* BLAST reconstruction can be used with non-Cartesian sampling patterns [2]. *k-t* SENSE using non-Cartesian sampling has, however, not yet been demonstrated. In this abstract we extend the non-Cartesian *k-t* reconstruction to include the complementary information contained in multiple receiver coils (i.e. non-Cartesian *k-t* SENSE) and we apply the method to real-time radial imaging of speech production, which is a useful diagnostic tool for patients with speech defects. This application is ideal for this type of reconstruction for two reasons: 1) since it is a real-time application, a trajectory which has integrated training data is preferable, 2) the FOV is approximately circular and consequently there is little overhead in using a radial acquisition.

**Theory and Methods.** The general *k-t* SENSE reconstruction equation can be written as $\boldsymbol{\rho}_{x,f} = \left(\mathbf{E}^{\mathrm{H}}\boldsymbol{\Psi}_{k,t}^{-1}\mathbf{E} + \boldsymbol{\Theta}_{x,f}^{-1}\right)^{+}\mathbf{E}^{\mathrm{H}}\boldsymbol{\Psi}_{k,t}^{-1}\mathbf{m}_{k,t}$, where $\boldsymbol{\rho}_{x,f}$ is the reconstructed signal in *x-f* space (the spatial-temporal frequency domain), $\boldsymbol{\Psi}_{k,t}$ is the noise covariance matrix as defined in Ref. [3], $\boldsymbol{\Theta}_{x,f}$ is the signal covariance matrix, $\mathbf{m}_{k,t}$ is the measured signal, superscript "+" denotes the Moore-Penrose pseudo inverse, superscript H denotes the complex conjugate transpose and **E** is the encoding matrix describing the encoding from *x-f* space to *k-t* space data, i.e. Fourier transform from the temporal frequency domain to the temporal domain, multiplication with the complex coil sensitivities, Fourier transform to *k*-space and sampling on an arbitrary trajectory. The signal covariance matrix is usually not known and is therefore replaced with a diagonal matrix $\mathbf{M}_{x,f}^{2}$ which contains the squared estimated signal intensities in *x-f* space as obtained from the training data (i.e. prior information). The inversion indicated above cannot be performed directly due to the large size of **E**. In this work we use the Conjugate Gradient (CG) method to solve the following system of linear equations $\mathbf{D}\left(\mathbf{E}^{\mathrm{H}}\mathbf{E} + \mathbf{M}_{x,f}^{-2}\right)\mathbf{D}(\mathbf{D}^{-1}\boldsymbol{\rho}_{x,f}) = \mathbf{D}\mathbf{E}^{\mathrm{H}}\mathbf{m}_{k,t}$, where **D** is a diagonal preconditioning matrix used to improve convergence and the noise covariance matrix has been eliminated using noise decorrelation as described in [3]. The multiplication with **E** and $\mathbf{E}^{\mathrm{H}}$ are replaced with gridding operations and FFTs. The new non-Cartesian *k-t* SENSE reconstruction was applied to radial datasets from simulations and *in vivo* data acquired in a volunteer. In both cases the matrix size was 128 by 128 and 25 projections were acquired for each time frame (acceleration factor 8). The sampling pattern was rotated for each time frame such that 8 consecutive frames could be added to form a fully sampled *k*-space. The *in vivo* resolution was 2.0x2.0mm$^2$ and the frame rate was approximately 13 frames per second. The *k-t* SENSE reconstructions were compared to a sliding window reconstruction which was modified such that the fully sampled center of *k*-space was updated every frame whereas the outer parts of *k*-space were updated only every 8 frames. We will refer to this reconstruction as "SW-Keyhole" [4].

**Results.** The simulation results are seen in Fig. 1, where *x-t* plots have been made from a location passing through the lips. The *k-t* SENSE reconstruction shows better temporal fidelity in the *x-t* plots, i.e. there is less blurring of the sharp edges. This is also confirmed with the RMS reconstruction error depicted in Fig. 2, where the error for non-Cartesian *k-t* BLAST is shown for reference. The *in vivo* results (Fig. 3) confirm the findings from the simulations.




**Conclusions.** We developed a new reconstruction method for *k-t* SENSE applied to non-Cartesian trajectories. The reconstruction has lower RMS reconstruction error than a sliding window alternative and shows improved temporal fidelity. We have demonstrated an application (speech) for this method which benefits from the specific advantages of both radial imaging and *k-t* SENSE.

**References.** [1] Tsao J, et al., MRM 50:1031–1042 (2003).[2] Hansen MS, et al., ISMRM 2005. [3] Pruessmann KP, et al., MRM 46: 638-651. (2001). [4] Lethmate R, et al. MAGMA 16:21-28 (2003).