View Sharing in slice direction for continuously moving table acquisitions: Application to TOF venography

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Introduction

To increase the temporal resolution in time-resolved MRI, several view sharing (VS) techniques have been developed. Typically, high spatial frequencies are not fully sampled for all time frames and data from the different time frames are combined to generate full k-space data [1, 2]. In this study the VS concept was applied to share data between different slice positions for axial continuously moving table (CMT) acquisitions. The k-space was divided into three segments for each slice and k-space data was shared for different slice positions. By the variation of the patient table velocity the degree of VS could be flexibly adjusted. The feasibility of CMT VS was tested on healthy volunteers for the application to CMT Time-of-Flight (TOF) venography of the peripheral vessels [3].

Methods

For VS CMT acquisitions the full k-space was divided into three segments. The central segment was acquired for each second slice while the upper and the lower segments were measured for each fourth slice (Fig. 1). The number of VS slices n_{VS}, which can be reconstructed from k-space data assigned to n slice positions (slice thickness sth), is $n_{VS} = [(n-1)/2]$. If the velocity of patient table motion v was chosen according to $v=v_{auto}=sth/(\#PE \cdot TR)$, where $\#PE$ is the number of phase encoding steps, the data acquisition could be performed three times faster compared to conventional full k-space acquisition. The reduction of the table velocity to $v=c \cdot v_{auto}$ $(c<1)$ decreased the degree of VS since k-space segments assigned to overlapping slices were combined. The effective slice thickness of reconstructed VS slices was defined by $sth_{VS}=n/n_{VS} \cdot sth$ (for overlapping slices sth_{VS} has to be multiplied by c).

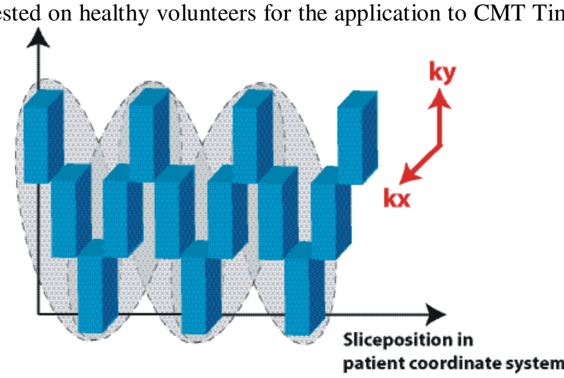

Fig.1: Acquisition scheme for the CMT VS technique. The k-space was divided into three segments. The central segment was acquired for each second slice. One VS slice is reconstructed by combining three adjacent k-space segments as highlighted in grey.

The CMT VS technique was implemented using a CMT FLASH sequence. 2D axial TOF images of the legs were acquired on a 1.5 T system (Magnetom Avanto, Siemens, Medical Solutions, Erlangen) using three different protocols: CMT VS without slice overlap ($v=v_{auto}=3mm/s$), CMT VS with slice overlap ($v=2/3 \cdot v_{auto}=2mm/s$), fully sampled data where no VS was used ($v=v_{auto}=1mm/s$). Further sequence parameters were: TR/TE=19.23/3.95ms, bandwidth=180Hz/Pix, FOV=400x260mm^2, matrix=320x181, sth=3.5mm, flip angle=45°. For successful fat suppression in CMT TOF images each protocol had to be performed twice, once saturating the signal of inflowing arterial blood and once saturating the signal of inflowing arterial and venous blood [3]. Image-by-image subtraction and maximum intensity projection (MIP) of the subtraction CMT TOF data resulted in images of the venous vessel structure.

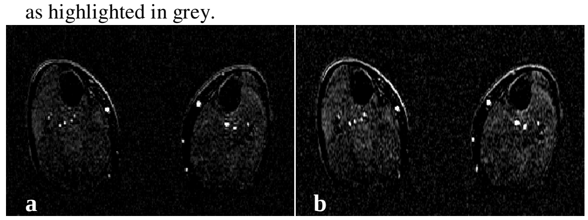

Fig.2: Comparison of an axial subtraction CMT TOF image of the lower leg reconstructed from full k-space data (a) and the corresponding VS slice reconstructed by removing retrospectively 2/3 of the same k-space data.

Results and Discussion

Figure 2a shows an axial subtraction CMT TOF image reconstructed from full k-space data without slice overlap. In Fig. 2b the corresponding axial VS slice is shown which was reconstructed by removing retrospectively 2/3 of the same k-space data. Both images are of comparable image quality and show the small distal veins. A coronal MIP of subtraction CMT TOF images computed from fully sampled k-space data is displayed in Fig. 3a. Figure 3b shows a magnification of the marked area in Fig. 3a. Figures 3c and d depict the same enlarged image sections computed from acquired VS data with slice overlap (c) and without slice overlap (d). Note that accelerated data acquisition resulted in signal loss for small vessel diameter (yellow arrow in Fig. 3c and d). By reconstructing VS data from overlapping slices, the degree of VS can be reduced and even in the lower leg images of similar quality can be achieved compared to fully sampled data. Further acceleration might include the integration of parallel imaging techniques. The final aim is to accelerate the acquisition as far as possible, to make the VS technique applicable to CMT TOF arteriography. Due to the pulsatile flow inside the arteries, it might be necessary to acquire several k-space segments for one time point in the ECG cycle. Corresponding segments with respect to the position in the ECG cycle can then be grouped to full k-space data to obtain artefact free images of the arterial tree. The appropriate numbers of segments and the optimal acquisition pattern for arteriography have to be investigated in future works.

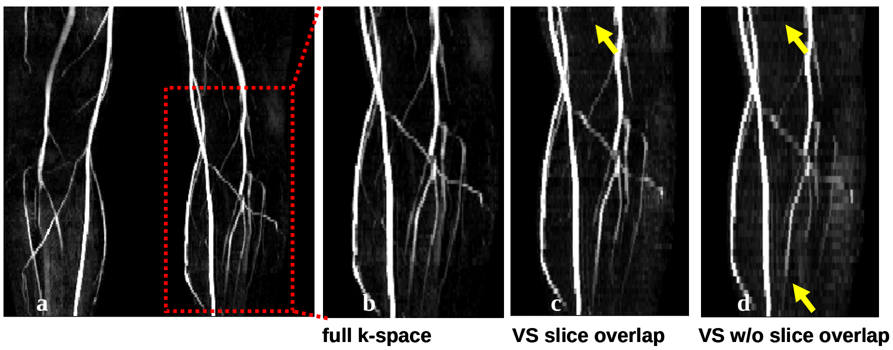

Fig.3: Coronal MIP of subtraction CMT TOF images reconstructed from fully acquired k-space data (a) and enlarged image section (b). Enlarged image sections of coronal MIPs computed from acquired VS data with (c) and without slice overlap (d).

References: [1] Korosec FR et al. *Magn Reson Med 1996*;36:345-351. [2] Doyle M et al. *Magn Reson Med 1995*;33:163-170. [3] Huff S et al. *Proceedings ISMRM*, 2008.