MR-based FoV Extension in Whole-Body MR/PET Using Continuous Table Move

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Introduction: MRI off-center imaging is widely used in many clinical applications. Particularly in whole-body MR/PET attenuation correction, an MR-based field-of-view (FoV) extension is of emerging interest [1]. However, gradient nonlinearities and B_0 inhomogeneities often hamper an accurate spatial encoding at the edges of large FoVs [2, 3]. Body regions outside the specified FoV such as the patient's arms might appear geometrically distorted and might be accompanied by signal voids, such that a post-processed rectification is not sufficient. Recently, we proposed a method to axially extend the FoV by determining an optimal readout gradient field which locally compensates B_0 inhomogeneities and gradient nonlinearities [4]. The optimal gradient is space-dependent and thus has to be modified for each slice position. However, the number of slice positions can be reduced to one using Continuous Table Movement (CTM) [5]. In this work a combination of the mentioned axial FoV extension and CTM is presented. In experiments on volunteers a significant distortion reduction has been achieved at off-center positions of up to 300 mm off from the iso-center.

Materials and Methods. All scanning was performed on an integrated MR/PET hybrid whole-body imaging system (Biograph mMR, Siemens Healthcare Sector, Erlangen, Germany). The system-specific B_0 inhomogeneities of the main magnetic field and the nonlinearities of the gradient field were systematically measured once using an MR probe array. The probe contains 24 NMR probes rotating around the magnetic field axis with 24 angular positions per turn. Geometrical distortions of the volunteer's arms due to B_0 inhomogeneities δB_0 and gradient nonlinearities δB_G at off-center positions were locally compensated using an optimized space-dependent readout gradient $G_{RO,opt}(x,y,z) = -\delta B_0(x,y,z)/c(x,y,z)$, with the relative error of the gradient field $c(x,y,z) = \delta B_{G,RO}(x,y,z)/G_{RO}$ as described in [4]. An optimal readout gradient corresponding to zero distortion was calculated for the right volunteer's arm position and the left volunteer's arm position at slice position z=0 (iso-center). The HASTE sequence was modified to continuously slide the volunteer through the optimized slice at an off-center position during measurement using CTM.
In a volunteer experiment transversal slices at an off-center position (x = -300 mm) were acquired during continuous table movement using a non-optimized readout gradient and an optimized readout gradient. The axial FoV was set to 500 mm with 1.95*1.95 mm^2 in-plane resolution and 5 mm slice thickness. The total FoV in z-direction was set to 705 mm with a distance factor of 50 % between transversal slices.

Results. Figure 1 shows a composed localizer image of the volunteer acquired at four bed positions. Typical truncation artifacts occurred at the edge of the FoV. In the off-center CTM measurement the expected distortions of the volunteer's arm lying outside the specified FoV (Fig. 2A) were significantly reduced using an optimized readout gradient (Fig. 2B).

Discussion. The amplitude of in-plane distortion in readout direction depends on the B_0 inhomogeneities and gradient nonlinearities and on the readout gradient. Therefore, a space-dependent profile of truncation can be observed in Fig 1. Using the CTM technique, the total FoV of the volunteer is measured at the identical scanner's slice position, here at z = 0, due to continuous sliding of the volunteer through one slice position. Thus, the amplitude of in-plane distortion is equal for all slice positions in table moving direction (Fig 2A). The distortion due to B_0 inhomogeneities and gradient nonlinearities at axial off-center positions can be compensated using an optimized space-dependent readout gradient for a specific slice position. Truncation artifacts of the total FoV can be significantly reduced by sliding the volunteer through the optimized slice (Fig 2B). Therefore a whole-body acquisition of the complete anatomy with an axial FoV of up to 600 mm and an arbitrary total FoV in table moving direction can be acquired. Therefore the reported bias of the PET reconstruction due to whole-body FoV limitations in the MR-based attenuation correction map might be reduced.

Conclusion. The proposed method of an axial FoV extension using an optimized readout gradient field combined with continuous table movement significantly reduced typical truncation artifacts at off-center positions. Therefore, the technique has the potential to improve MR-based large FoV attenuation correction in combined whole-body MR/PET hybrid imaging.

References. (1) Delso G et al., Med Phys 2010, 37:2804-12. (2) Baldwin L N et al., Med Phys 2007, 34:388-99. (3) Bakker C et al., Magn Reson Imaging 1992, 10:597-608. (4) Blumhagen J O et al., 2011, In Proc. 19th Annual Meeting ISMRM (#2693). (5) Zenge et al., MRM 2009, 61:867-73.

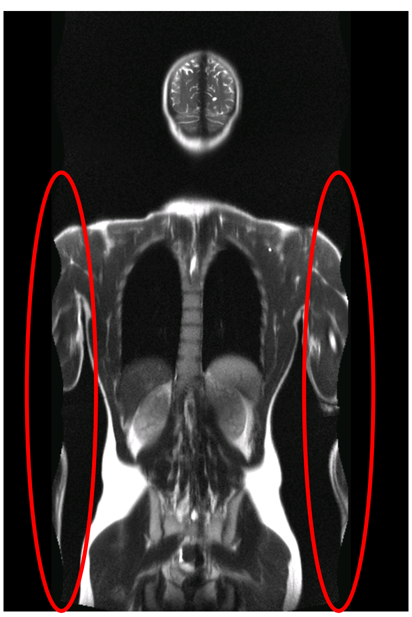

Figure 1: Localizer showing truncation artifacts.

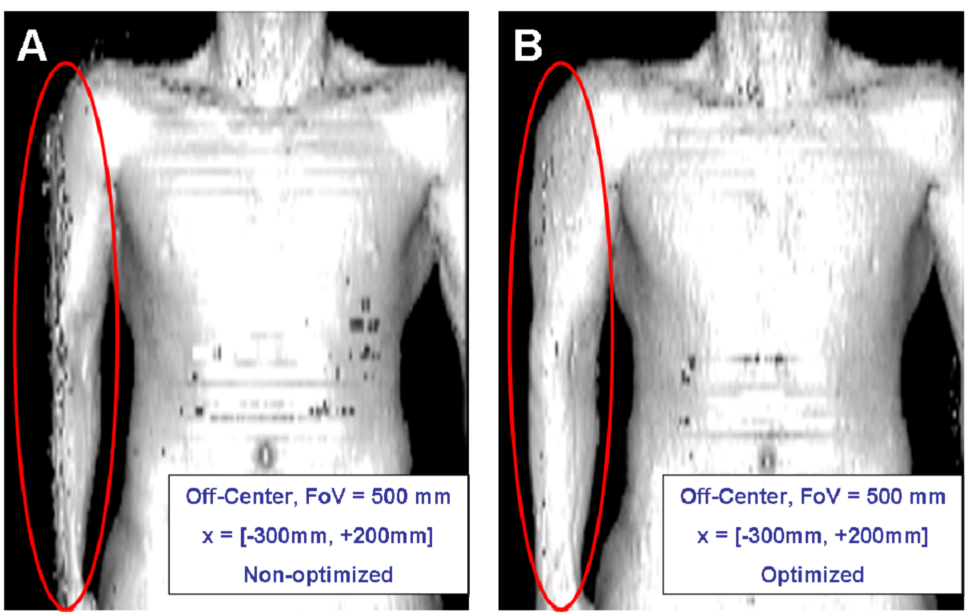

Figure 2: 3D shaded surface display of volunteer measured with an axial oriented HASTE sequence using continuous table movement. Distortions and signal voids at off-center positions (A) can be reduced using an optimized readout gradient (B).