Feedback field control in 3D T_2* imaging at 7T

Yolanda Duerst[1], Michael Wyss[1], Bertram J Wilm[1], Benjamin E Dietrich[1], Simon Gross[1], David O Brunner[1], Thomas Schmid[1], and Klaas P Pruessmann[1]
[1]*ETH Zurich, Zurich, ZH, Switzerland*

INTRODUCTION

MR imaging relies on a stable magnetic background field superimposed with time varying gradients. However, physiological effects such as breathing or limb motion of the patient change the distribution of susceptible tissue and hence lead to unwanted spatiotemporal field variations. This effect scales with field strength and has been reported to cause image distortion in 2D brain MRI at 7T [1-3].

3D imaging sequences with long echo times are expected to be particularly sensitive to respiration induced field changes. In this work the application of real-time feedback field control [4] is tested for removing related image artifacts without the need to change the imaging sequence or image reconstruction. In addition the findings were compared to 2D imaging.

METHODS

All measurements were performed on a 7T Philips Achieva Scanner (Philips Healthcare, Cleveland, USA). 3D T_2*-weighted gradient echo images were acquired (TR: 50 ms, TE: 25 ms, resolution: 0.7 mm isotropic) in transverse and coronal orientation. Each scan was acquired without and with real-time field control [4]. For comparison a 2D multislice scan was acquired covering approximately the same region (FOV: 240x190 mm^2, TR: 1000 ms, TE: 25 ms, in-plane resolution: 0.3 mm, slice thickness: 1.5 mm, 20 slices).

RESULTS

While in the 2D images distinct artifacts such as signal loss, ringing, or ghosting are visible (Fig. 1a), 3D acquisition suffers predominantly from general image blurring (Fig. 1b). Additionally, the 3D images show strong ringing artifacts in the vicinity of cavities that were removed when stabilizing the field (Fig. 1c). The effect is highlighted on the difference images which show an amplitude change of 10 % in the corresponding regions. The 3D images acquired in the coronal plane show intensity variations which are particularly prominent in the cerebellum (Fig. 1d). By applying real-time feedback, these intensity modulations were diminished, however not completely removed. This is also apparent in the difference image where a change of up to 20 % in image magnitude is observed.

DISCUSSION / CONCLUSION

We qualitatively assessed artifacts in 3D T_2* images which tend to suffer from a general blurring, as compared to 2D T_2* imaging where the artifacts have more distinct features. This blurring is probably due to the inherent averaging that 3D acquisition performs over the duration of the scan. Thereby the effects of oscillatory field changes induced by respiration are rendered less crisp and rather appear as blurring. We demonstrated that real-time field control reduced image blurring which lead to visually sharper images. Furthermore, ringing artifacts around cavities have been strongly mitigated.

When compared to imaging in the transverse plain, the intensity changes in the coronal images showed more pronounced and spatially extended ringing artifacts.

Since shim feedback control was limited to correction fields of 3rd order spherical harmonics, some of the breathing related field changes might not have been fully corrected. Especially in the lower parts of the head, pronounced higher order field fluctuations may be expected. Increasing the number of field probes and shim terms may allow for further improved image quality in these regions.

Generally, real-time field control proved to successfully stabilize respiration induced field changes and thereby enhance the image quality of 3D T_2*-weighted MRI. This could help to make 3D imaging more reliable and to advance its inherent benefits to routine use.

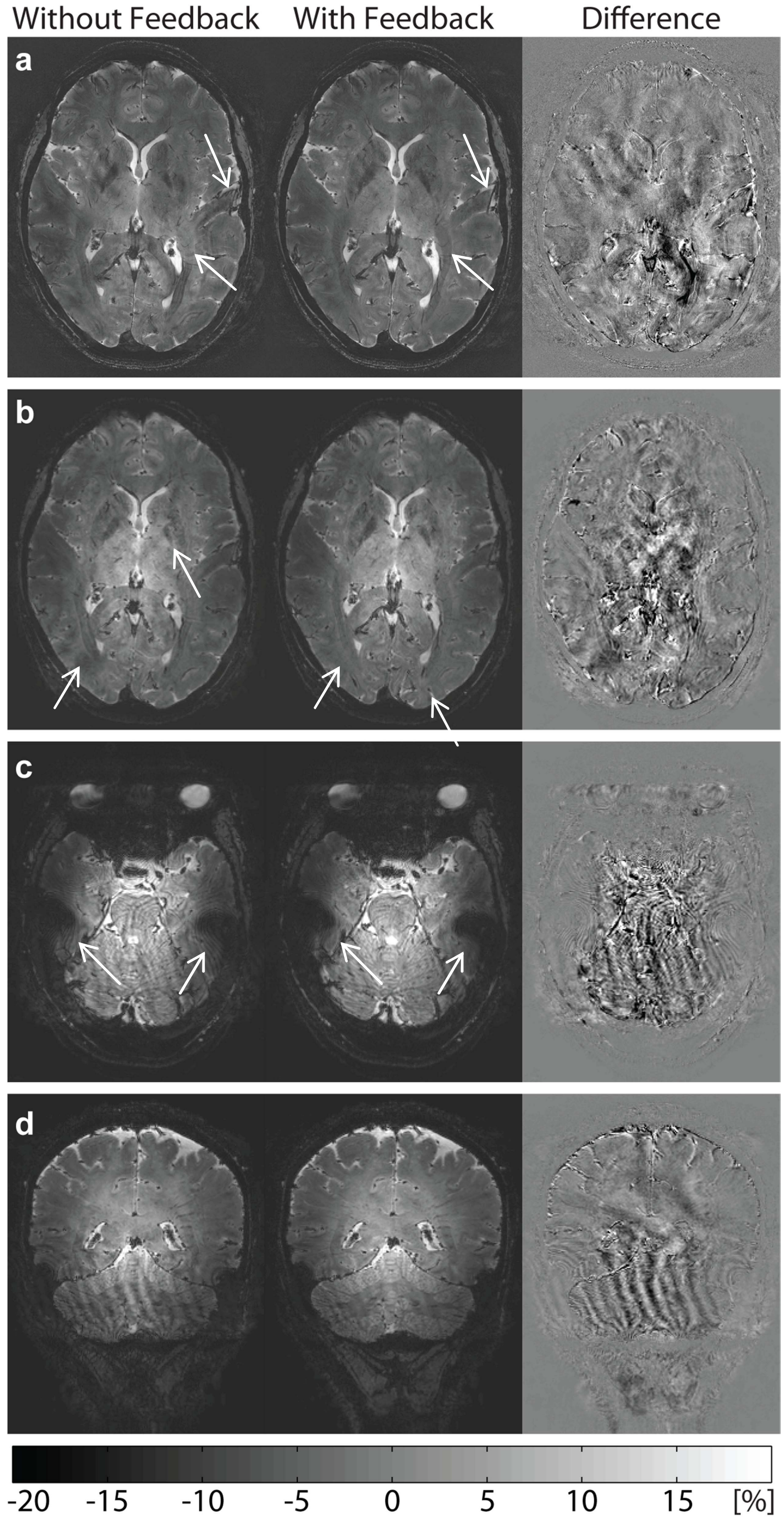

Fig. 1: 2D (a) and 3D (b-d) T_2-weighted gradient echo images acquired without and with feedback in transverse (a-c) and coronal (d) orientation. Difference images are scaled to percent of the maximum amplitude in the non-corrected case.*

REFERENCES
[1] Van de Moortele et al., MRM 2002;47:888-895
[2] Van Gelderen et al., MRM 2007;57:362-368
[3] Versluis et al., NeuroImage 2010;51:1082-1088
[4] Duerst et al., Proc. ISMRM 2013;p.669