Reduced acquisition time in fat saturated abdominal imaging using HoPE: a clinical evaluation

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Introduction

Frequency selective fat saturation is an established method to increase diagnostic value in fast T1w contrast enhanced abdominal imaging. However, it reduces scan efficiency due to short acquisition windows between successive saturation preparations (limited by the T1 relaxation time of the fat signal) and relatively long preparation times of the fat saturation itself. Longer acquisition windows increase scan efficiency but lead to imperfect and inter-slice varying fat suppression [1, 2]. A method that allows prolonging the inter preparation distance while maintaining in-slice saturation quality and inter-slice saturation homogeneity was proposed in 2002: Homogenous phase encoding (HoPE). HoPE uses inversion pulses instead of saturation pulses and a special k-space reordering scheme that acquires equal phase encoding steps of any slice at equal time distances from the inversion preparation [2].

The aim of this work was to evaluate the performance of HoPE in a clinical study with respect to reduced measurement time. A minimum of only one fat preparation pulse was applied each TR resulting in an increase of up to 40% in scan efficiency over the conventional standard protocol which applies 3 saturation pulses each TR.

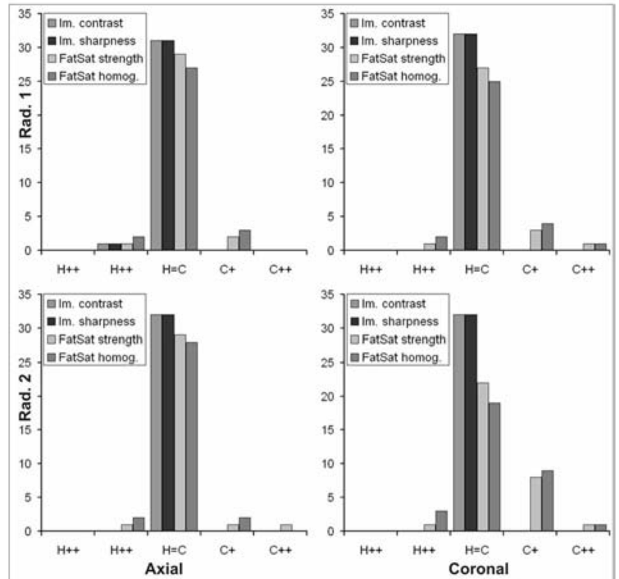

Fig. 1: Qualitative analysis results for axial and coronal protocols for both radiologists (Rad.1 & Rad.2). 5-point scale for rating: HoPE much better (H++), HoPE better (H+), HoPE equal to Conventional imaging (H=C), HoPE worse (C+), and HoPE much more worse (C++) compared to conventional imaging.

Method

32 (14w/18m, 57y±16y, 48kg ±13kg) patients underwent abdominal, contrast enhanced, T1w fast gradient echo imaging during breath hold. In addition to the clinical routine examinations corresponding HoPE acquisitions were performed with identical contrast and resolution determining measurement parameters.

In the axial protocol 39 slices were acquired with TR=120ms, TE=2.78ms, a=80°, and BW=260Hz/pixel. With conventional fat saturation 8 slices were measured each slice package covering 39 slices in 5 breath holds. Using HoPE the efficiency was increased to 13 slices each package covering 39 slices in 3 breath holds. In the coronal protocol 24 slices were acquired in 3 breath holds using TR=111ms, TE=2.78ms, a=80°. Parallel imaging was used with 50 reference lines, acceleration of 2 and Grappa reconstruction. Using HoPE the number of breath holds was reduced from 3 to 2.

All measurements were performed on a 1.5T Magnetom Avanto (Siemens Medical Solutions, Erlangen, Germany). Contrast agent was: 0.1 mmol/kg Magnevist (Schering), 1 ml/s flow, and additional 30ml NaCL.

For qualitative analysis all patients were investigated by two independent radiologists. The following criteria were rated on a 5-point scale (HoPE much better – better – equal – worse – much worse in comparison to conventional imaging): image sharpness, image contrast, strength of fat suppression, and in-plane homogeneity of fat suppression. The evaluation was conducted separately for axial and coronal protocols. Artifacts were rated on a 3-point scale (strong, low, none) for all protocols: ringing, pulsation, movement.

For quantitative ROI analysis, signal to noise ratio (SNR) was calculated for different tissues (liver, spleen, kidney and muscle). This analysis was performed on 6 healthy volunteers without contrast agent due to fast contrast agent kinetic in living tissue. The difference in SNR between conventional and HoPE was analyzed for each volunteer.

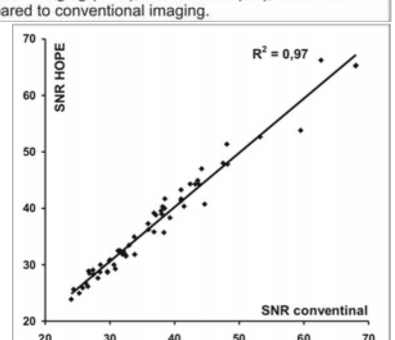

Fig. 2: Quantitative analysis results from 6 healthy volunteers. SNR of HoPE is plotted against SNR of conventional imaging. Values correlate with a high coefficient R^2=0.97.

Results

Figure 1 shows the qualitative evaluation of the protocols of both radiologists. Image sharpness and contrast of HoPE were rated in nearly all cases equal to conventional imaging (with a single exception: in one axial acquisition HoPE was rated better). In most cases (107, respectively 99 out of 124) fat saturation strength and homogeneity were rated equal. In 15 out of 64 coronal cases, however, in-plane saturation homogeneity was better in conventional imaging, whereas in 5 cases it was better in HoPE. A closer analysis showed that in all cases the reason was residual fat signal from subcutaneous fat in coronal slice orientation (see fig. 3c&3d). In 97% of the cases, artifacts were rated equal for HoPE and conventional imaging. In 9 cases pulsation artifacts were rated better in HoPE.

The SNR analysis was performed in 60 pairs of ROIs covering all assessed tissues. The average difference between the calculated SNR values in the conventional and HoPE images was 3.84% (Min=0.0%, Max=9.28%, STD=2.44%). The values correlate with R^2=0.97 (see fig. 2). Therefore, SNR from HoPE and from conventional imaging can be assumed to be equal.

Fig. 3: Image examples from patient study
3a) Axial conventional imaging and with HoPE (**3b**). No differences can be seen in image quality or fat suppression.
3c) Coronal conventional imaging and with HoPE (**3d**). Increased sensitivity to off-resonance leads to decreased suppression in-plane homogeneity using HoPE (red arrow). Intra abdominal fat is suppressed equally in HoPE and conventional imaging.

Discussion

The HoPE scheme provides a robust and stable technique for reducing the measurement time in our protocols to 40%, resp. 33% in fat saturated gradient echo imaging. The quantitative analysis resulted in same SNR for HoPE and conventional imaging. Also image sharpness and contrast were rated to be equal, whereas a slight improvement against pulsation artifacts was achieved in HoPE.

The observed reduction in suppression of subcutaneous fat signal in coronal images is explained by a slightly increased sensitivity to off resonance effects. However, the suppression of intra abdominal fat signals was equal to conventional imaging. Therefore the diagnostic value was not compromised using HoPE.

References

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[2] Fautz HP, et al., MRM 48:745-753 (2002)