Phantom optimisation for gas based colongraphy

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Introduction: Recent studies have indicated that MR colonography without colonic cleansing has potential for polyp and tumour detection[1]. Careful choice of diet combined with utilisation of oral contrast media to "tag" faeces can modify intraluminal signal to consistently differ from tumour, allowing discrimination. We propose to evaluate a strategy using the oral contrast agent ferric ammonium citrate (FAC) with complimentary dietary manipulation to shorten both luminal T1 and T2 values and gaseous insufflation[2,3]. Comparison of several sequences suitable for breath-hold imaging will aim to improve sensitivity and specificity for polypoid lesions.

This work aims to develop a phantom to simulate the colon with polypoid lesions of varying sizes and surrounding intra-abdominal fat in order to optimise the sequence parameters for the colonic imaging strategy described above.

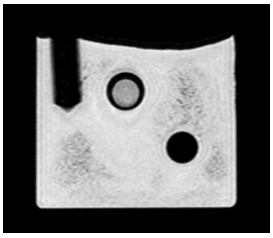


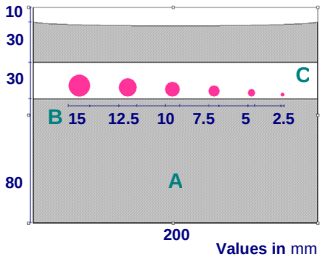
Figure 1. T1w FAME MR image of phantom for SNR measurement: TX151 gel tube in glass bore.

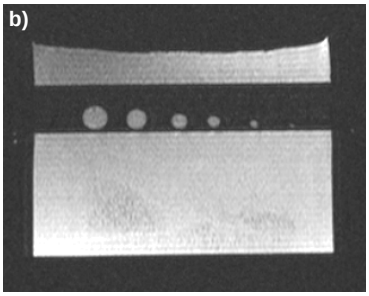
Materials and Methods: The phantom was constructed from an acrylic box filled with coconut oil and containing a 30mm diameter glass tube of similar susceptibility to human tissue. Colonic lesions were simulated using TX151 gels (Oil centre research, LA) with T1 and T2 relaxation times similar to those of colorectal tumour. For T1w imaging simulated polyps with a T1 relaxation time of ~730ms (measured by IR technique) was formulated from: 9% TX151 gel, 91% distilled degassed water doped with 0.125mM gadolinium. For T2w imaging simulated polyps with a T2 relaxation time of ~120ms (measured with multi-echo SE) was formulated from: 10% TX151 gel, 90% distilled degassed water.

All investigations were performed on a 1.5T (Echospeed+, GEMS Milwaukee, WI) MRI system. The following sequences suitable for breath-hold imaging were investigated using a 44cm FOV: 2D T2w SSFSE (TEeff=80ms) 2D PDw SSFSE (TEeff=33ms), 3D T1w FAME (TE/TR=1.1/4.3) and 3D T1w FGRE (TE/TR=0.6/1.6ms). The following parameters were varied: T1w FAME and FGRE: flip angle (5 – 60°) and slice thickness (3 – 9mm); T2w and PDw SSFSE: slice thickness/gap (3/3 – 6/0mm).

Quantitative SNR analysis of sequence parameter variation was undertaken on images obtained using a transmit/receive quadrature head coil and samples of the TX151 gels in 21.75 mm diameter plastic tubes within the phantom (figure 1). Additionally qualitative analysis was undertaken using an 8-channel torso phased-array coil with spherical TX151 gel 'polyps' in the phantom (figure 2). Sequences were investigated at both best and worst slice positions (i.e. center of 'polyps' at slice center and off-center). Images were reviewed for confidence of 'polyp' detection by 2 experienced observers in consensus using a 5-point scale and blinded to position and sequence details.

Figure 2a)





Sagittal schematic section **a)** and T1W FAME image **b)** through phantom filled with coconut oil (**A**). Six spherical 'polyps' (**B**) of TX151 gel (2.5 - 15mm diameter) coated with ~1mm paraffin wax (to maintain shape) were positioned in the lumen of glass tube (**C**) for qualitative analysis.

Results: The SNR values for T1w FAME (figure 3) and FGRE decreased as flip angle increased, giving a best value of 5° in both cases (Ernst angle ~ 4°). Confidence scores were optimal in both cases at 10°. Confidence scores for polyps of 5mm or larger were high for all slice thicknesses of 3 - 9mm irrespective of centering. Smaller polyps were intermediate to low confidence for all thicknesses but deteriorated above 6mm.

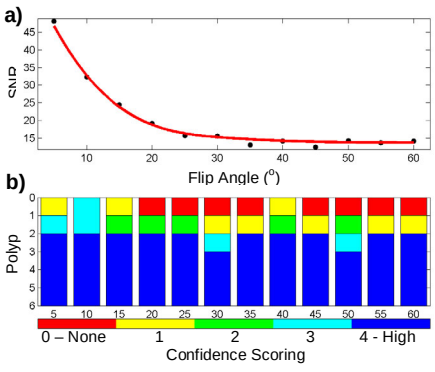


Figure 3. a) SNR and **b)** 'polyp' visualization confidence scores by polyp (1 = 2.5mm, 6 = 15mm) vs flip angle variation in T1w FAME images. Confidence value – color bar.

T2w and PDw SSFSE SNR values improved by approximately 30% as slice thickness/gap ratio decreased from 6/0 - 3/3mm (for a 6mm total thickness+gap). Confidence scores for polyps of 5mm and less were low irrespective of the thickness and gap. The 7.5mm polyps were best visualized using either a 6/0 or 5.5/0.5 thickness/gap on both PDw and T2w.

Conclusion: A phantom with realistic relaxation parameters suitable for the evaluation of T1w and T2w MR colonography sequences has been developed. Initial results suggest that the slice thickness/spacing compromises required for acceptable breath-hold imaging times is likely to limit the detection of small (<5mm diameter) polyps.

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References:

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