

A New Validated MRI Method For Measuring Colonic Transit Time

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Introduction: Functional gastrointestinal disorders (FGIDs) are conditions of altered gut motility and sensitivity. Currently, the diagnosis of FGIDs is symptom based but there is a need for more objective biomarkers including GI transit tests to define underlying abnormalities more objectively and this allows better targeting of treatment. Some of these tests are invasive causing patient discomfort; others expose the patient to radiation which is undesirable. **Aim:** to validate a new MRI method for measuring colonic transit time (CTT) and assess its reproducibility.

Method: **Subjects:** 20 healthy volunteers (12 males, 8 females), aged 21-70 years, with no previous history of GI disease took part in this study. The study was approved by the local ethics committee and all subjects gave written informed consent. **Study protocol:** Subjects attended twice on two separate weeks (test-retest). On each test week 2 transit tests were applied **(A) MR Transit markers:** Subjects swallowed 5 capsules filled with 0.4ml Gadolinium-DOTA contrast agent (DOTAREM[®]) 24 hours before undergoing an MRI scan. Subjects were scanned in a 3T Philips Achieva scanner with a MTX body coil and coronal scans were acquired at 2 stations with 30mm overlap. (i) T1 weighted 3D FFE (TR/TE=2.9/1.3 ms, FA=10°,FOV=250x398x160mm³, ACQ res 2.3x2.3x4mm³) was used to count and locate the number of pills in the colon. The MTX body coil was also used to receive signal to increase portability of the technique and simplify positioning of subjects (ii) mDIXON¹ (TR/TE1/TE2=3/1.07/1.9ms, FA=10°,FOV=250x371x200mm³, ACQ res 1.8x1.8x3.6mm³, SENSE=2, receive coil 16-Ch XL) was used to clarify the position of the pills, if the T1W FFE image was not conclusive, using a movie made from MIPs of the water only images generated at 18 angles around the body. A 16-Ch XL coil was used for reception to allow mDIXON reconstruction. **(B) Radiopaque Markers (ROMs)** using the validated method of Metcalf²: Each volunteer swallowed 20 ROMs on 3 consecutive days, and a single abdominal x-ray (AXR) was taken on day 4. **Data analysis:** (A) The Gadolinium-DOTA filled capsules were scored depending on their position within the colon as assessed by the weighted average (Fig. 1), and to reduce the effect of outliers, a weighting factor was calculated for each pill depending on the difference of the pill score from the median pill score. For a difference of 0 and 1 the weighting factor was 1 for all differences larger than 1 the weighting was the inverse of the difference. The weighted average position score of the MRI marker pills was determined. (B) The number of ROMs observed on the AXR at day 4 were counted and multiplied by 1.2h², to give a CTT value in hours. **Statistics:** Data was tested for normality and then Spearman's rank correlation was used to assess the degree of correlation between the two measurements.

Results: Fig 2 shows an example MR image of the transit markers in vivo and Fig 3 shows the corresponding x-ray required for the Metcalf method of assessing transit. There was good correlation between transit measured using ROMs and the Gadolinium-DOTA capsules (Fig 4), Spearman's $r=0.85$ $p<0.0001$. A Bland Altman plot showed good reproducibility with a mean difference in the weighted average of the pills position of 0.03 units between visits.

Discussion: The MR images showed excellent contrast of the pills within the intestinal lumen. Moreover, the mDIXON MIP data also showed excellent delineation of the colon without the use of bowel preparation due to the short T1 of colonic chyme, making scoring of the pills simple. Good correlation was observed between MRI and AXR data. In addition the MR data showed good repeatability between visits. Our novel MRI technique for quantifying CTT provides a convenient test for patients which is simple to carry out and interpret, non invasive, and does not expose subjects to ionising radiation. MRI images provide excellent 3D spatial resolution, allowing the gut to be viewed from all angles, unlike the single film x-ray. Gadolinium capsules could provide an alternative method test to measuring CTT in clinical practice.

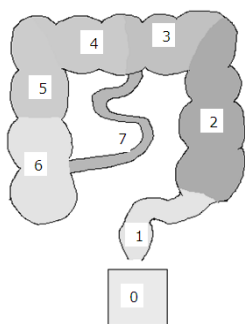


Figure 1. Segmentation of the colon: 7= small bowel, 6= cecum, 5= ascending colon, 4= right transverse colon, 3= left transverse colon, 2=descending colon, 1= sigmoid/rectum, 0=excreted.



Figure 2. Example T1 weighted MRI image showing marker pills.



Figure 3. Example AXR showing radio-opaque markers.

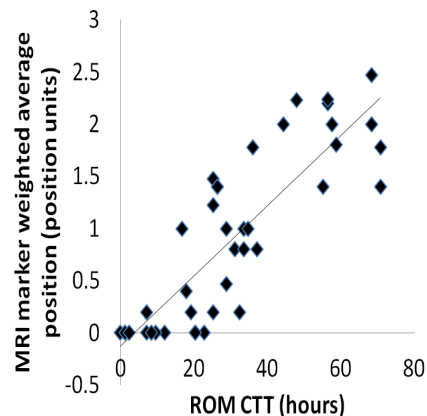


Figure 4. Showing the correlation between ROMs and MRI marker capsules.

References:[1]Eggers H. et al. *Magnetic Resonance In Medicine*. 2011. [2] Metcalf A. M. et al. *Gastroenterology*. Funded by the Medical Research Council.