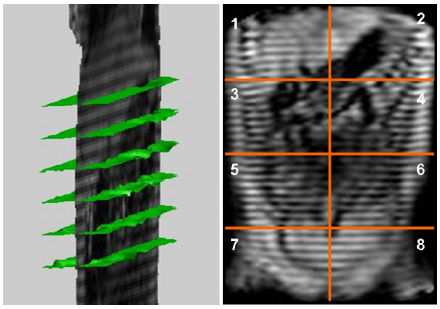
Bowel motility assessment during free breathing using Continuously Tagged MR imaging

Marije P. van der Paardt[1], André M.J. Sprengers[1], Rolf M. Lamerichs[1,2], Aart J. Nederveen[1], and Jaap Stoker[1]
[1]*Department of Radiology, Academic Medical Center Amsterdam, Amsterdam, Netherlands,* [2]*Philips, Eindhoven, Netherlands*

Introduction

The challenge of bowel motility measurement lies in evaluation of the total volume of intestine and in using a non-invasive technique allowing repeated assessment over a large time frame [1, 2]. Recently, the ability to extract motion information over long time frames in an automated fashion was demonstrated with Continuously Tagged MR imaging in a single volunteer [3]. Continuously Tagged MR imaging induces a stripe pattern in MR images from which motion information can be extracted when the pattern is deformed by tissue motion [3] (Figure 1).
This study presents bowel motility assessment in a group of ten healthy volunteers after administration of a spasmolytic agent by using Continuously Tagged MR imaging and automated post processing.

Figure 1 (left): *the tag pattern over the mid coronal slice; the slices were set in a 3D perspective for visualization purposes of the tag planes.*
Figure 2 (right): *the FOV was divided in octants for spectral analysis.*



Methods

Continuously Tagged MR employs conventional MR-tagging, modified for non-periodic motion. This enables motility assessment during free breathing with broad coverage. After approval of the medical ethical committee and written informed consent, 10 healthy volunteers were scanned. Prior to imaging, the volunteers fasted for 3 hours and received an oral preparation of 1000 ml Mannitol 2.5% solution. Subjects were scanned in supine position for eight minutes. The tagging prepulse was applied prior to the dynamic scan followed by a 195 ms delay, enabling motility to cause tag deformation. Images were acquired using a Philips 3T Intera scanner with a Sense XL 16 channel torso coil. The voxel resolution was 3 mm isotropic, FOV= 400x400x36mm (12 slices), TR/TE = 2.9/1.8 ms. Dynamic readout time using a 3D FFE was 98 ms resulting in a sampling frequency of 3.36 Hz.
After two minutes a spasmolytic agent, glucagon [1 mg Glucagen, Novo Nordisk Farma], was administered intravenously during data acquisition, in order to manipulate the bowel motion. To assess alterations in motility after administration of glucagon, each dataset of eight minutes was divided in four equal temporal sets of two minutes (period 1 to 4). Spectral analysis of deformation fields extracted from the tag pattern was performed for each set. For quantification of motility the spectral power was divided by the maximal spectral power in each volunteer resulting in a motility index ranging from 0 (i.e. no motion) to 1 (breathing motion) [3]. Motion spectra were calculated per voxel with a frequency domain of 0.0084 -1.66 Hz and spectral resolution of 0.0084 Hz. The spectra were averaged per octant over the FOV (Figure 2). Spectral analysis was performed for sixteen frequency bands of 0.033 Hz and statistical comparison was done for multiple paired groups (Friedman test).

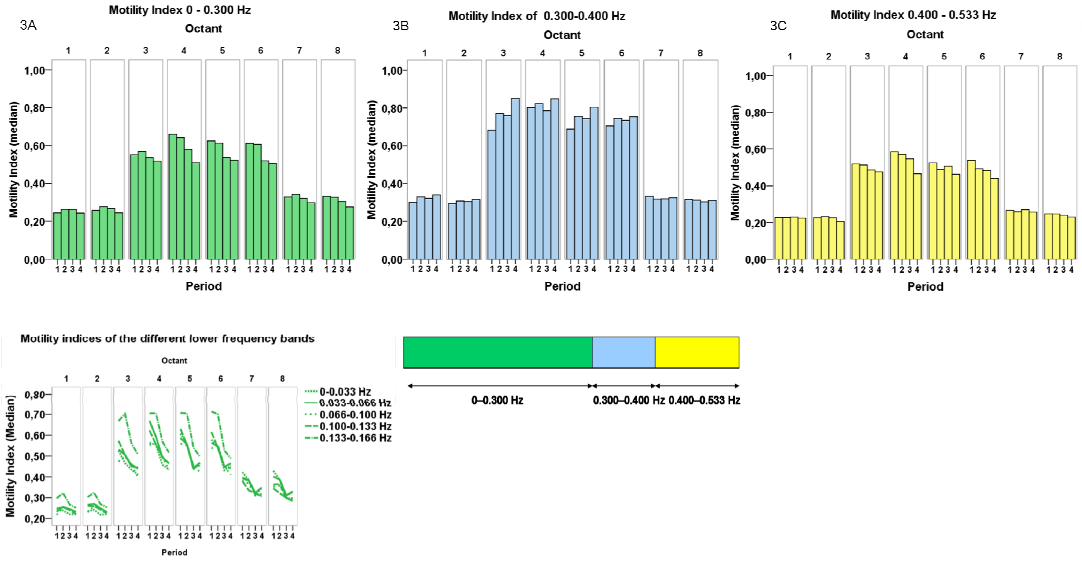


Figure 3 *demonstrates a low motility index for octant 1,2,7,8.*
A*: shows a decrease in motility index in octant 3 to 6 over period 1 to 4 for frequency bands ranging from 0.008 to 0.300 Hz.*
B*: illustrates no significant decrease in motility index in frequency bands ranging from 0.300 to 0.400 Hz.*
C *shows the higher range of frequency bands. A significant decrease for the motility index is noticeable in four octants.*
D *represents the motility index of the separate lower frequency bands.*
E *demonstrates frequency ranges.*

Results

Motion spectra were successfully acquired in all ten volunteers. The first temporal set (period 1) demonstrated baseline bowel motility of the individuals. Spectral analysis showed low motility indices for the four outer octants (Figure 3, octant 1,2,7,8) due to low SNR and field heterogeneity. We noticed significant differences in all frequency bands except for the range 0.300 - 0.400 Hz (blue), as these frequencies correspond with the breathing. In the lower frequency bands (green) from 0 to 0.300 Hz a significant decrease in motility index ($p<0.0005$) could be observed, indicating a decrease in bowel motion after administration of glucagon. Decreases were most significant in the lowest frequency bands (0 - 0.166 Hz, Figure 3D). Higher frequencies (yellow) of 0.400 to 0.530 Hz showed a decrease of the motility index over the periods, however less obvious ($p=0.001$).

Conclusion

This study demonstrates that continuously tagged MR is a non invasive method for bowel motility assessment during free breathing. This technique is capable of demonstrating significant changes in bowel motility after administration of glucagon.

1 Wakamiya et al JMRI 2011, **2** Froehlich et al JMRI 2005, **3** Anonymous