

# MRI assessed dysmotility and texture analysis in the terminal ileum and small bowel: A pilot study comparison between Irritable Bowel Syndrome (IBS) patients with bloating and healthy controls

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## Synopsis

Gastrointestinal symptoms in irritable bowel syndrome (IBS) occur without any obvious structural gut abnormality. This pilot study is based on abnormal ileo-caecal motility function suggested by wireless capsule data, with potential reflux of caecal contents back into the terminal ileum (TI). We compared constipation-predominant IBS (IBS-C) patients with bloating to healthy controls, through texture analysis and motility measures. We found TI temporal variation of motility was significantly higher in healthy controls. There was also a difference in the TI to small bowel texture analysis contrast ratio, but this was only significant in BTFE sequences.

## Introduction

Irritable bowel syndrome (IBS) manifests with recurrent gastrointestinal symptoms including abdominal pain, bloating, constipation and/or diarrhoea, in the absence of any demonstrable structural gut abnormality<sup>1</sup>. Disturbed motility is postulated as a key cause of symptoms. Wireless motility capsule studies suggest abnormal ileo-caecal motility in some IBS patients, with reflux of caecal contents into the terminal ileum<sup>2</sup>. Anecdotally, radiologists also report “faecalisation” of terminal ileum luminal content on MRI performed in patients with IBS-C.

MRI is increasingly established as a powerful non-invasive tool to study bowel structure, content, and function (motility). It may therefore be a useful biomarker of IBS, aide in phenotyping patients more accurately and increase our understanding of its pathophysiology.

The purpose of this study was to investigate whether MRI can demonstrate differences in enteric motility and terminal ileum luminal content between IBS patients with abdominal bloating (IBS-C) and healthy controls (HCs). Specifically, we investigated texture analysis and motility derived measures.

## Methods

*Subjects:* 15 IBS patients with abdominal bloating and 20 HCs underwent MR enterography.

*Scanning:* Motility was imaged using a cine series of 2D coronal, balanced gradient sequences acquired during breath-holds to cover the whole small bowel (SB) volume using routine motility imaging parameters<sup>3</sup>. Anatomical images were also acquired using balanced sequences at a higher spatial resolution (figure 1).

*Motility Analysis:* For each 2D cine sequence the frames were registered using an optic-flow based registration technique<sup>4</sup>. A motility map and a temporal variation map (figure 2) both summarising the variations in local expansion and contraction on a per pixel basis were calculated from the standard deviation of the Jacobian determinant of the deformation fields.

A total of 4 motility metrics were developed for the TI; 1) mean motility, 2) spatial variation (variability across ROI), 3) temporal variation (variability over time), 4) area of motile bowel.

*Texture Analysis:* 2 ROIs of identical shape and size were drawn on anatomical images: 1) in the TI and 2) in an oral contrast filled region of small bowel.

Gray level co-occurrence matrices (GLCMs) were calculated in 4 directions and for pixel distances from 1-4 using 32 gray levels. 3 summary measures were derived for each GLCM: 1) contrast, 2) energy and 3) homogeneity and then averaged for the 4 directions, providing 12 texture analysis measures per subject.

For each summary measure, the ratio between the TI and the SB was calculated at each of the 4 pixel distances.

*Statistical analysis:* For both motility and texture analysis, a Student's t-test was used to compare IBS patients and HCs.

## Results

The TI temporal variation (metric 3) was significantly higher ( $P = 0.02$ ) in HCs (mean = 0.024,  $n = 16$ ) than IBS patients (mean = 0.010,  $n = 14$ ) (figure 3). There were no significant differences for metric 1 ( $P = 0.10$ ), metric 2 ( $P = 0.14$ ) or metric 4 ( $P = 0.36$ ).

The best texture analysis measure to discriminate between the two subject groups was contrast at a pixel distance of 1 pixel (figure 4). The ratio of TI to SB (TI/SB ratio) was higher in IBS patients (mean ratio = 1.82,  $n = 15$ ) than HCs (mean ratio = 1.56,  $n = 18$ ), but this did not reach significance ( $P = 0.32$ ) (figure 5).

## Discussion

In this pilot study we demonstrated higher temporal variability of motility in healthy controls. This suggests that symptoms in IBS could in part be caused by aberrant terminal ileum motility, being consistently switched “on” or “off”. This would affect transit of luminal contents from the terminal ileum into the colon and is a plausible explanation for the observation of caecal-ileal reflux using wireless motility capsule. Altered motility and TI filling may cause aberrant viscerosomatic reflexes, resulting in abdominal bloating.

A higher TI/SB contrast ratio in IBS suggests a mixture of bowel contents in the TI, including possible faecal reflux from the colon compared to more homogeneous SB mannitol filling as part of MRE protocols in healthy controls. In this small pilot study we were unable to detect a significance difference between HCs and IBS. Data were acquired from multiple scanners and a significant contrast-ratio difference was observed in a sub-set of 4 patients from one scanner. Further investigation is required to optimise scan parameters for differentiating between intestinal contents.

## Conclusion

Low motility temporal variation in the terminal ileum could potentially be a biomarker for bloated IBS patients. Texture analysis shows promise in its ability to differentiate between various luminal contents. Optimisation of sequences to increase sensitivity to luminal contents may lead to a more robust detection of differences using texture analysis.

## Acknowledgements

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## References

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## Figures

MR Parameter			
Scan Type	Motility	BTFE	FISP
Field Strength	1.5 or 3T	3T	1.5T
TR (ms)	3.6-4.3	2.5 or 3.7	3.6-4.3
TE (ms)	1.7-2.2	1.2 or 1.8	1.8-2.2
Flip Angle	20-62	45	46
Spatial Resolution (mm)	2.5x2.5	1x1	1x1
Slice Thickness (mm)	5 or 10	5	4
Temporal Resolution	1 image per second	n/a	n/a

Figure 1: MR parameters for motility and anatomical sequences.

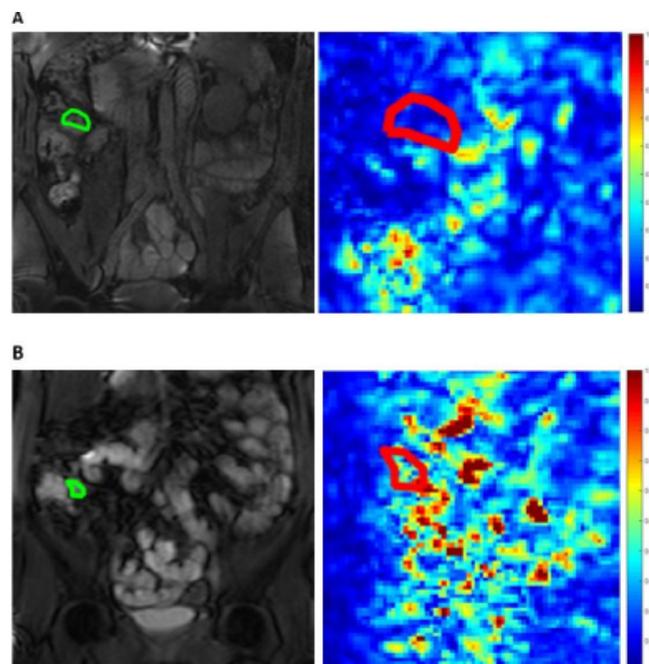


Figure 2: Two examples of coronal temporal variation maps based on the standard deviation of the Jacobian determinant with colourbar showing low (blue) to high (red) temporal variation of motility. A region of interest was drawn in the terminal ileum with a low temporal variation seen in the IBS patient (A) and a high temporal variation seen in the healthy control (B).

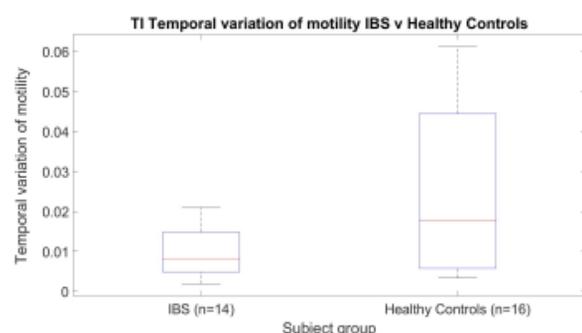


Figure 3: Boxplot comparison of the TI temporal variation of motility between IBS patients (n=14) and healthy controls (n=16).

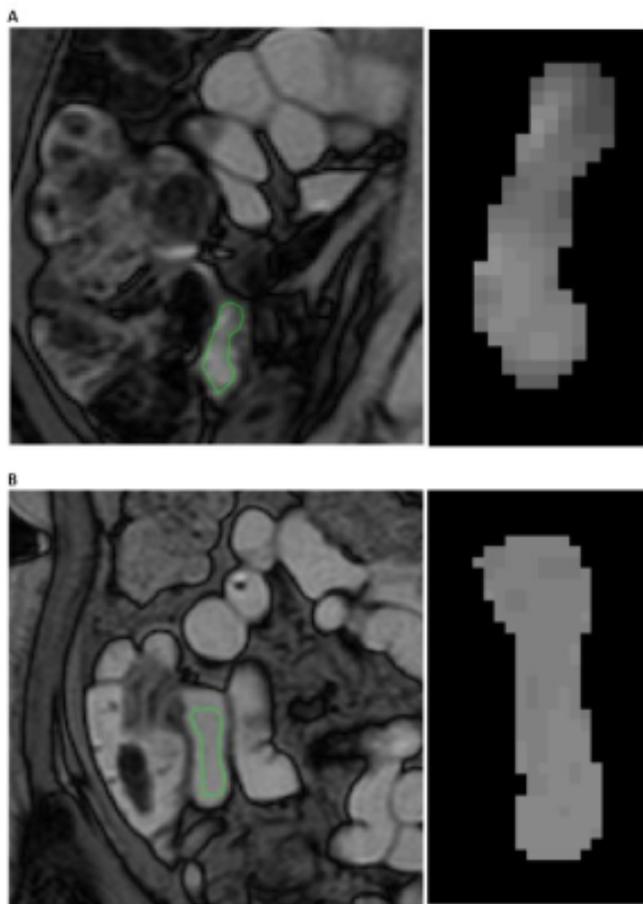


Figure 4: Two examples of texture analysis in the terminal ileum of an IBS patient (A) and a healthy control (B) with the scaled images used in the calculation of the GLCM (right) derived from the corresponding coronal anatomical images (left). A high texture analysis contrast of 1.78 is shown in the IBS example (A) and a low texture analysis contrast of 0.25 is shown in the HC example (B) for the GLCM calculated using a pixel distance of 1 pixel and averaged over all directions.

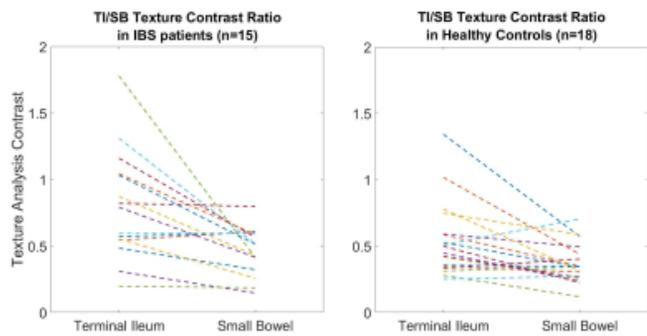


Figure 5: Line plot to show the texture analysis contrast at a pixel distance of 1 pixel for the terminal ileum and the small bowel for IBS patients (left) and HCs (right).