Small Bowel Strictures in Crohn's Disease: a quantitative investigation of intestinal motility using MR enterography

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Introduction:

Small bowel strictures are common in Crohn's disease and often present a therapeutic dilemma. In patients with abdominal symptoms it is not always clear if the stricture is responsible, nor whether surgical removal would be effective. The natural history of Crohn's strictures is also poorly understood. For example it is unclear whether pre-stricture small bowel dilatation represents an irreversible failure of bowel motility function, or whether function can be restored after medical or surgical therapy. Dynamic motility sequences are increasing used in Magnetic Resonance Enterography (MRE) and may provide insights into the functional significance of stricturing disease and the subsequent natural history. Validated motility analysis software is now available which can derive quantitative information pertaining to small bowel motility both within areas of stricturing and the immediate upstream bowel[1]. The purpose of this study was to quantify MRE derived small intestinal motility in Crohn's disease related strictures, and to investigate potential differences in upstream bowel, with and without secondary dilatation.

Methods:

Patients: Review of the departmental database revealed 24 patients (mean age 32 range 18-79, 8 female) fulfilling the eligibly criteria of Crohn's disease and small bowel stricturing identified by MRE. Six of the cohort had undergone previous surgery. A stricture was defined as a focal decrease in luminal diameter of at least 10% compared to normal bowel. The immediate upstream bowel of the stricture was classified as "non-dilated" if the luminal diameter was not more than 50% greater than nearby normal bowel or "dilated" if greater than 50%. In total 16 and 8 patients had non-dilated and dilated pre-stricture bowel respectively.

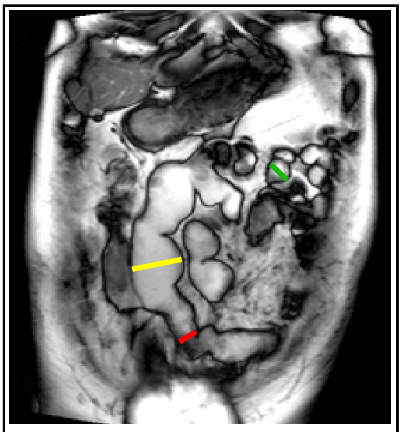

Fig.1 Stricture with prominent up-stream dilatation. Red ROI at the stricture (S), Yellow pre-stricture (PS) and green upstream in normal bowel loop (N)

MRI Protocol: All MR scans were performed using a 1.5T Siemens Avanto scanner (Siemens, Erlangen, Germany). Patients fasted for 4h and then ingested 1.5L of Locust bean gum and 2% mannitol solution before adopting the prone position in the scanner. For motility analysis, sequential coronal TRUEFISP (20 second breath hold, TR=(3.74-3.98ms), TE=(1.87-1.99ms), slice thickness 10mm, 0.8sec/slice) sequences were acquired through the abdomen to include the small bowel volume (range 8 to 16 acquisitions per patient).

Quantitation of small bowel Motility: (i) Image Registration: An optic-flow based registration technique was extended to incorporate image intensity changes[1]. The 2D slices of a time series were registered to a representative slice to generate deformation fields and maps of intensity change.

(ii) Region of Interest (ROI) placement: Two observers (consultant radiologist with 7 year's experience of MRE and trainee with 1 year) drew a linear 'region of interest' (ROI) within stricture (S) using the motility stack best delineating its full length. A second ROI (PS) was placed in the bowel immediately upstream of the stricture and a third (N) in normal small bowel within the same anatomical segment (ie jejunum, ileum or terminal ileum) (fig 1). The software algorithm then automatically propagated all regions of interest through the motility time series.

(iii) Motility quantitation. A motility index was derived using the software by quantifying the motion of pixels traversed by the ROI, expressed as the standard deviation of the Jacobian determinant (a measure of local area change). In addition, the lengths of ROIs across the time series were used to provide a median luminal diameter for the bowel.

Statistics: i) Motility and luminal diameter variance were compared across S, PS and N using ANOVA and post-hoc analysis with Tukey Kramer statistics. Data was in addition split into dilated and non-dilated pre-stricture (PS) bowel. ii) The association between luminal diameter and motility was investigated using Pearson's correlation statistics. iii) Dilated Vs non-Dilated motility was assessed with T-test.

Results

Figure 2 summarises motility data with confidence intervals for normal bowel (N), stricture (S), and pre-stricture (PS) and split PS.

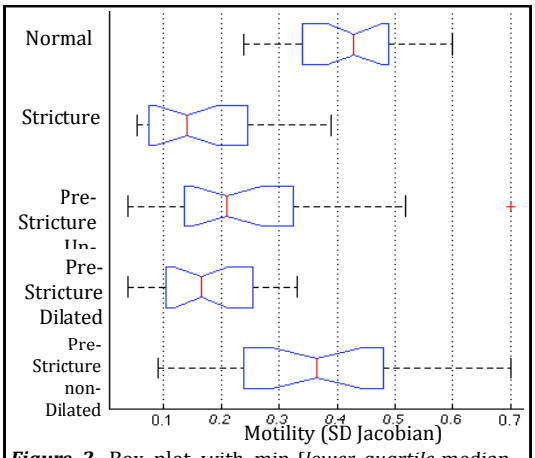

Figure 2. Box plot with min-[*lower quartile*-median-*upper quartile*] – max where chevrons note confidence intervals. For convenience, all groups are represented here.

Motility and luminal diameter variance: There was a highly significant difference in motility between N (mean 0.42), S (mean 0.17) and PS (mean 0.25) (ANOVA $p = 1.2e^{-8}$). Post-hoc analysis confirmed normal bowel (N) motility was significantly higher than both S & PS. Median luminal diameter also was significantly different between S (mean 13mm) and both PS (mean 33mm) and N (mean 16mm) (ANOVA $p = 2.96e^{-12}$). Post-hoc analysis confirmed a significant difference between PS and both S and N, but not between S and N.

Luminal diameter and motility: There was a significant negative correlation between PS diameter and respective motility ($R = 0.42$, $p = 0.04$) and N diameter and respective motility ($R = 0.58$ $p = 0.002$).

Dilated Vs non-Dilated PS Motility: Motility in dilated PS (mean 0.18) was significantly lower than non-dilated PS (mean 0.45) (T-test $p = <0.001$).

Discussion:

The use of dynamic MRE data to quantitatively analyse motility around small bowel strictures in Crohn's disease has not been previously reported. Our data confirm reduced motility within the stricture itself. However interestingly we demonstrated a significant difference between motility in non-dilated and dilated upstream bowel with decreased motility in the latter. Furthermore, we found a negative relationship between luminal diameter and motility immediately upstream of the stricture. This could imply some form of "motility failure" by the time pre-stricture bowel becomes very dilated. These data provide new insights into the effect on bowel motility by stricturing Crohn's disease. The technique may have an important future role in assessing the functional significance of strictures, their relationship to symptoms, prognostication and ultimately therapeutic strategy.

References: 1. Odille F., *et al.* 2011 MRM – *in press* and Odille F. *et al.* 2011 ISMRM