

Rapid 3D T1-mapping of inflamed bowel in Crohn's Disease at 3.0 T

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Purpose/Introduction

Crohn's disease (CD) is a transmural, granulomatous inflammatory bowel disease. Grading of disease severity is important in CD in order to be able to optimally determine treatment strategy and response to treatment. It is thought that the severity of inflammatory disease correlates with mesenteric vascularisation and vessel permeability. An indirect measure of permeability can be inferred from the Gadolinium (Gd)-concentration in the tissue of interest, and in order to obtain an exact measure of Gd-concentration the absolute T1 relaxation times must be calculated. Calculation of relaxation times for every pixel of a parametric image (i.e. a T1-map) could possibly provide an objective, quantifiable, and reproducible means of determination of CD activity. However, the making of T1-maps in the bowel remains a challenging task due to the long times required for T1-mapping and the short time frame available for scanning due to respiration and bowel peristalsis.

The purpose of our study was to determine the feasibility and value of T1-mapping in abdominal MRI for CD.

Subjects and Methods

Ten patients with active luminal CD as assessed at ileocolonoscopy (CS) were included. Biopsies were taken for histopathological examination. For each patient inflammatory activity was determined, based on endoscopic and histopathological results. C-reactive protein values (CRP) were determined as biological marker of active inflammation. MRI examinations were performed within two weeks after CS. One patient suffered from claustrophobia, leading to an incomplete examination and exclusion from analysis.

T1-measurements in multiple slices were performed with the classical Look-Locker (LL) sequence in combination with a segmented 3D Turbo Field Echo sequence and implemented on a Philips 3.0 T Intera scanner with a matrix size of 128x128, slice thickness of 7 mm and flip angle of 8 degrees. 20 alpha pulses with an interpulse interval of 197 ms were applied within a TR of 4.0 s. In total 4 inversion pulses (shots) were used, resulting in an overall scan time of 16 seconds. The total number of slices in the acquired volume amounted to 14 with the volume positioned at the most proximal affected bowel loop that was assessed at CS. T1-maps in the abdominal region were acquired before and after intravenous administration of Gadodiamide (Omniscan) in one breath-hold during an MR-bowel imaging procedure (20 mg of butylscopolamine bromide was administered intravenously to reduce peristalsis and 1.5 liter Mannitol-solution was ingested to distend the small bowel).

T1-maps were produced off-line using home-written software that interpolates the LL recovery curves and calculates T1-values. Inflamed bowel loops were delineated and mean Gd-concentrations were subsequently calculated.

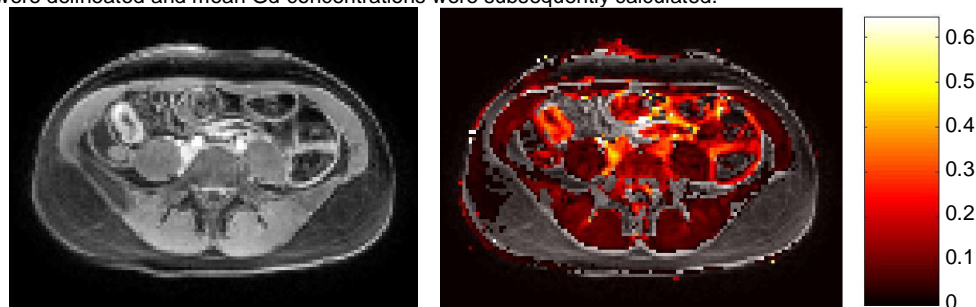


Fig. 1a: (left image): post-contrast T1-weighted transversal image.

Fig. 1b: (right image): identical post-contrast T1-w transversal image with Gadolinium map displayed as overlay. Concentrations in the actively inflamed bowel loop are as high as 0.5 mmol/l.

Results

In three patients mild disease was diagnosed, in six patients moderate to severe disease (see Fig. 2) was diagnosed. CRP ranged from 1.1 to 176.4 mg/l (mean 37.2 ± 60.1). It was feasible to calculate Gd-maps for all patients. A statistically significant correlation was seen between CRP-values and Gd-concentration in the affected bowel ($r=0.68$, $p=0.04$). The mean Gd-concentration was higher in patients with moderate to severe disease than in patients with mild inflammatory activity (Fig. 3).

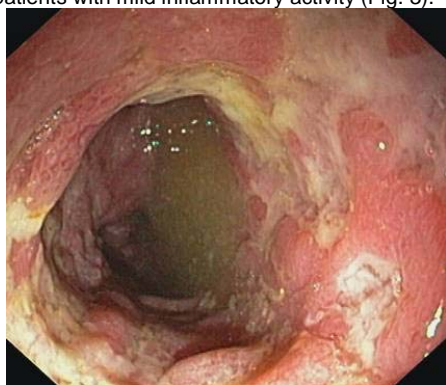


Fig. 2: Endoscopic view of the severely inflamed bowel of the patient depicted in Fig. 1.

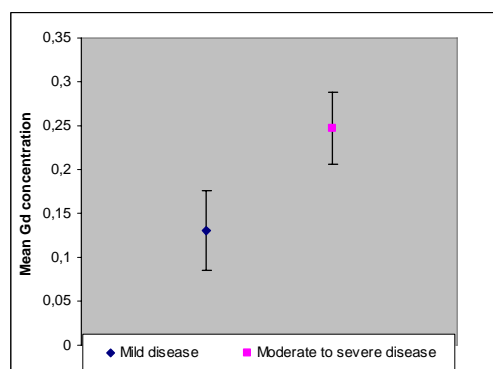


Fig. 3: Mean Gd-concentration calculated in the actively inflamed bowel. For the calculation of Gd-concentrations a relaxivity value of $4.5 \text{ mmol}^{-1} \text{ s}^{-1} \text{ kg}$ was used.

Discussion/Conclusion

We have shown the feasibility of rapid T1-mapping at 3.0 T in luminal CD. This technique allows for quantitative assessment of contrast agent concentration, thus permitting permeability imaging in areas that suffer from important motion problems.