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Quantitative bowel apparent diffusion coefficient measurements in children with inflammatory bowel disease are not reproducible☆

T. Watson [a], A. Calder [a], J.L. Barber [a,b,*]

[a] Department of Radiology, Great Ormond Street Hospital for Children, London, UK
[b] Department of Radiology, St George's University Hospitals NHS Foundation Trust, London, UK

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AIM: To investigate the intra-observer and interobserver variability of quantitative apparent diffusion coefficient (ADC) measurements in children with inflammatory bowel disease.

MATERIALS AND METHODS: Nine readers were recruited. Six magnetic resonance imaging (MRI) enterography cases with known active disease in the jejunum, terminal ileum, or colon were analysed. Readers measured repeat ADC values from the known diseased site and an unaffected site, at two sittings.

RESULTS: Seven readers completed the study. The Lin concordance coefficient for intra-observer agreement was poor (0.844, 95% confidence interval [CI]: 0.77, 0.896). Bland–Altman limits of agreement for intra-observer agreement were 0.66×10^{-3} mm^2/s (95% CI: 0.46, 0.86), and -0.56×10^{-3} mm^2/s (95% CI: −0.36, −0.76). Therefore, a single measured value would be compatible with no disease, superficial ulceration, or deep ulceration according to published thresholds. Interobserver variability was poor to moderate across all observers (intraclass correlation coefficient [ICC]: 0.51, 95% CI: 0.27, 0.77). Between the two best-agreeing observers, agreement was good using the ICC (ICC 0.85, 95% CI: 0.43, 1.0), but poor using the Lin correlation coefficient (Lin 0.83, 95% CI: 0.65, 0.93), and Bland–Altman.

CONCLUSION: The intra-observer and interobserver agreement is inadequate to allow accurate characterisation of disease activity using previously published thresholds. Qualitative ADC assessment may be preferable.

Introduction

The role of magnetic resonance enterography (MRE) in the diagnostic evaluation of small bowel disease in paediatric inflammatory bowel disease is well established.[1] Novel therapies for the treatment of inflammatory bowel disease, such as biologics, are driving a growing interest in newer techniques to enable monitoring of treatment efficacy. Diffusion-weighted imaging is one of the more common such techniques and is a popular target for research.[2] Multiple studies have been published assessing the potential for quantitative analysis of diffusion-weighted imaging to discriminate active disease in inflammatory bowel disease. A range of proposed cut-off values have been generated as a result of this research with the aim of

☆ The quoted ADC values are measured in $\times10^{-3}$ mm^2/s.

* Guarantor and correspondent: J. L. Barber, Department of Radiology, St George's University Hospitals NHS Foundation Trust, Blackshaw Road, London SW17 0QT, UK. Tel.: +44 0 20 8725 2814.
E-mail address: j.barber@doctors.org.uk (J.L. Barber).

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differentiating between normal and diseased bowel using apparent diffusion coefficient (ADC) values.[3,4]

To date, however, there has been little attempt to assess the reliability of quantitative ADC measurements in the small and large bowel.[5–10] The studies performed so far have compared two readers only and examined interobserver variability, not addressing the potential for intraobserver variability. The results they have found have been mixed, with Lin concordance coefficients and intraclass correlation coefficients (ICC) for quantitative ADC measurements ranging from as high as 0.96 (Lin)[5] and 0.918 (ICC),[6] respectively, to as low as 0.71 (Lin)[8] and 0.63 (ICC).[9] Additional questions also remain incompletely addressed, i.e., whether measurement repeatability is influenced by the presence or absence of disease, by the segment of bowel affected, and the experience of the reader. In the present study, these questions regarding quantitative ADC measurement repeatability in paediatric inflammatory bowel disease using a multi-reader approach, were addressed in order to establish whether the reliability of ADC measurements is sufficient for distinguishing between diseased and normal bowel, and for grading severity.

Materials and methods

Six MRE studies were selected from a database of children with inflammatory bowel disease, who had active disease as assessed by a consensus panel of paediatric gastroenterologists and paediatric radiologists using a combination of endoscopy, histology, clinical activity scores, faecal calprotectin, biochemical markers, and imaging. The MRE studies had previously been scored using the London MRE scoring system[11] independently by the two authors (JB,TW). Three locations were assessed: jejunum, terminal ileum, and colon. From the database, studies were chosen with the highest mean scores (i.e., most abnormal) in these respective segments using the London MRE scoring system, provided the disease was well seen in the axial plane. There were two cases for disease in each location, one performed on a 3 T (Siemens Prisma, Erlangen Germany) and the other on a 1.5 T system (Siemens Avanto, Erlangen Germany). Imaging was reviewed for the purposes of this study on the standard departmental PACS (GE RIS-I 5.0, Chicago, IL, USA). Image analysis was performed using standard workstation tools.

The standard departmental MRE protocol has been published elsewhere.[12] DWI sequences are acquired at two b-values, 0, and 1,000. The image is acquired as an echo planar fat-saturated dataset with parallel imaging. The section thickness is 5 mm with an echo planar imaging (EPI) factor of 136, 5,400 ms repetition time (TR) and 99 ms echo time (TE), number of signal averages (NSA) 3. ADC maps are derived from these datasets.

Image interpretation

Nine candidates agreed to participate: four consultant paediatric radiologists (25, 10, 10, and 3 years' consultant experience), three paediatric radiology fellows (1, 3, and 3 years' paediatric radiology experience), and two radiology trainees (year 5 and year 2 of training). All observers performed the analysis independently, blinded to other results. Two members of this group, JB and TW have a particular interest and expertise in reporting of MRE (4 and 6 years, respectively). Candidates were blinded to all clinical details, but were given an axial half-Fourier single-shot fast spin-echo (HASTE) and axial true-FISP (true fast imaging with steady-state free precession) image indicating the area of abnormality for assessment. They were asked to draw a region of interest (ROI) on the ADC map to calculate an ADC value for that region of bowel (Fig 1). The instructions were

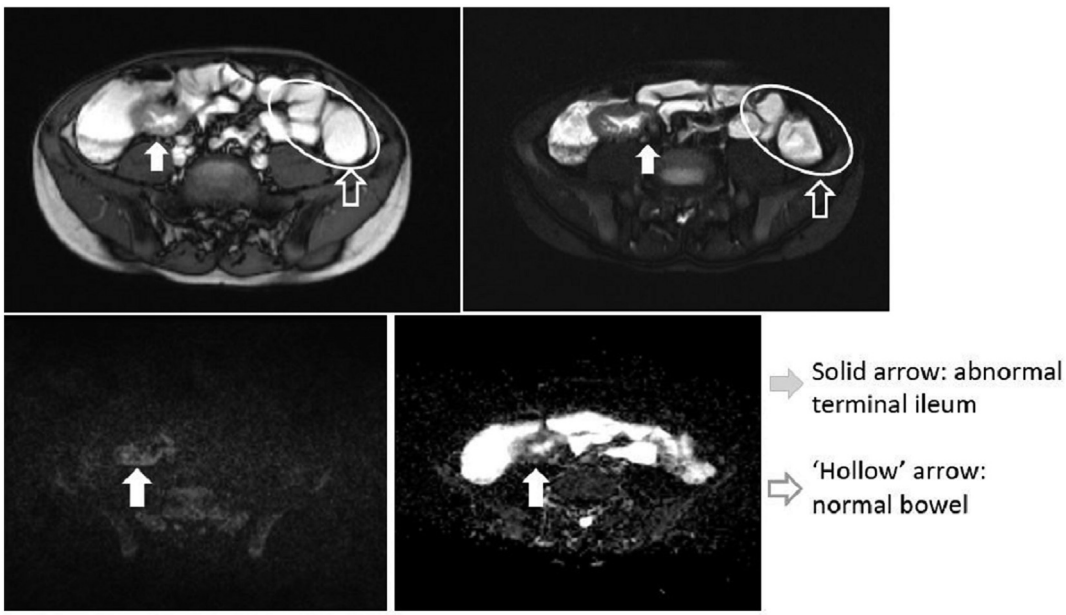

Figure 1 An example of the localisation images given to participants indicating areas to be measured.

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