

## Diffusion-weighted magnetic resonance imaging for predicting the response of rectal cancer to neoadjuvant concurrent chemoradiation

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### Abstract

**AIM:** To evaluate the clinical value of diffusion-weighted magnetic resonance imaging (DW-MRI) in predicting the response of rectal cancer to neoadjuvant chemoradiation.

**METHODS:** This prospective study was approved by our institutional review board, and informed consent was obtained from each patient. Fifteen patients (median age 56 years) with locally advanced rectal cancer were treated in our hospital from June 2006 to December 2007. All patients were stage III B-C accord-

ing to the results of MRI and endorectal ultrasound examinations. All patients underwent pelvic irradiation with 45 Gy/25 fx per 35 days. The concurrent chemotherapy regimen consisted of capecitabine 625 mg/m<sup>2</sup>, *bid* (Monday-Friday), and oxaliplatin 50 mg/m<sup>2</sup>, weekly. The patients underwent surgery 5-8 wk after the completion of neoadjuvant therapy. T downstaging was defined as the downstaging of the tumor from cT3 to ypT0-2 or from cT4 to ypT0-3. Good regression was defined as TRG 3-4, and poor regression was defined as TRG 0-2. Diffusion-weighted magnetic resonance images were obtained prior to and weekly during the course of neoadjuvant chemoradiation, and the apparent diffusion coefficient (ADC) values were calculated from the acquired tumor images.

**RESULTS:** Comparison with the mean pretreatment tumor ADC revealed an increase in the mean tumor ADC during the course of neoadjuvant chemoradiation, especially at the 2<sup>nd</sup> week ( $P = 0.004$ ). We found a strong negative correlation between the mean pretreatment tumor ADC and tumor regression after neoadjuvant chemoradiation ( $P = 0.021$ ). In the T downstage and tumor regression groups, we found a significant increase in the mean ADC at the 2<sup>nd</sup> week of neoadjuvant therapy ( $P = 0.011$ ; 0.004).

**CONCLUSION:** DW-MRI might be a valuable clinical tool to help predict or assess the response of rectal cancer to neoadjuvant chemoradiation at an early time-point.

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**Key words:** Locally advanced rectal cancer; Neoadjuvant chemoradiation; Diffusion-weighted magnetic resonance imaging; Apparent diffusion coefficient

**Core tip:** This original study prospectively evaluated the

clinical value of diffusion-weighted magnetic resonance imaging (DW-MRI) in predicting the response of rectal cancer to neoadjuvant chemoradiation. We found a strong negative correlation between the mean pretreatment tumor apparent diffusion coefficient (ADC) and tumor regression after neoadjuvant chemoradiation, as well as a significant increase in the mean ADC at the 2<sup>nd</sup> week in the T downstage and tumor regression groups. Therefore, DW-MRI might be a valuable clinical tool to help predict or assess the response of rectal cancer to neoadjuvant chemoradiation at an early timepoint.

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## INTRODUCTION

Neoadjuvant (chemo) radiation followed by total mesorectal excision has become the standard treatment for locally advanced rectal cancer (LARC)<sup>[1-3]</sup>. However, approximately 20%-30% of patients do not benefit from neoadjuvant treatment due to the radioresistance of the tumor<sup>[4]</sup>, and ineffective neoadjuvant treatment may result in unnecessary toxicity and expense as well as delays in receiving the proper treatment. Meanwhile, 10%-30% of patients with a pathological complete response (pCR) have a favorable long-term outcome<sup>[5]</sup>. Recently, data have even suggested that surgery is unnecessary for clinical complete responders<sup>[6]</sup>. To effectively guide patient-tailored treatments, reliable and early assessment of the treatment response is important.

Diffusion-weighted magnetic resonance imaging (DW-MRI) is a non-invasive functional MRI technique that is sensitive to the mobility of water protons in biological tissues, which is dependent on many factors, such as cell density, vascularity, the viscosity of the extracellular fluid, and cell membrane integrity<sup>[7-9]</sup>. The apparent diffusion coefficient (ADC) calculated from DW-MRI measurements can quantify and express these properties. However, published data on the value of DW-MRI as a predictive tool for anti-cancer treatment responses in patients with rectal cancer are scarce and conflicting. Most studies have found that the pretreatment ADC is negatively correlated with the response to treatment<sup>[10]</sup>. Furthermore, it is possible that necrotic areas with high pretreatment ADCs are less sensitive to radiation and chemotherapy, although several studies do not support this hypothesis, and others have obtained opposite results<sup>[11,12]</sup>. Therefore, we conducted this study to investigate the clinical value of DW-MRI as a predictor of the tumor response in patients receiving neoadjuvant chemoradiation therapy (CRT) for rectal cancer by measuring the tumor ADC.

## MATERIALS AND METHODS

Our institutional review board approved this prospective study, and informed consent was obtained from each patient.

### Patients and treatment

Fifteen patients (median age 56 years, range 32-69 years; 13 men and 2 women) with LARC were invited to participate in our study between June 2006 and December 2007. Each patient had histologically proven rectal adenocarcinoma of stage T3-T4 and was determined to be node-positive by endorectal ultrasound and pelvic MRI. Patients with a history of pelvic irradiation or chemotherapy, any other malignancy, or distant metastases were excluded (Table 1). The clinical and histopathological classification and stage according to the International Union Against Cancer TNM system<sup>[13]</sup> were recorded. Tumor regression grading was evaluated according to the criteria of Dworak *et al.*<sup>[14]</sup> (grade 0, no regression; grade 1, minor regression, dominant tumor mass with obvious fibrosis in 25% or less of the tumor mass; grade 2, moderate regression, 26%-50% of the tumor mass; grade 3, good regression, more than 50% tumor regression; and grade 4, total regression, no viable tumor cells, only fibrotic mass). A pCR was defined as the absence of viable tumor cells in the primary tumor and lymph nodes (ypT0N0). T downstaging was defined as the downstaging of the tumor from cT3 to ypT0-2 or from cT4 to ypT0-3. Good regression was defined as TRG 3-4, and poor regression was defined as TRG 0-2.

All patients received neoadjuvant concurrent CRT. Radiotherapy (RT) was delivered with a linear accelerator using 6- and 15-MV photons and a three-field technique (posterior-anterior and right and left laterals). Every patient underwent a planning computed tomography (CT) scan in the treatment position (prone position) using a belly board. Three-dimensional conformal RT was used for all patients based on the planning CT, with a total dose of 45 Gy at 1.8 Gy per fraction per day, Monday-Friday. Neoadjuvant chemotherapy was delivered concurrently with RT. Starting on day 1 of RT, patients received capecitabine 625 mg/m<sup>2</sup> orally, *bid* (Monday-Friday), and oxaliplatin 50 mg/m<sup>2</sup> weekly for five consecutive weeks. Surgical resection was scheduled for 5-8 wk after the completion of neoadjuvant treatment.

### DW-MRI

Each enrolled patient was examined by DW-MRI at six scheduled times. The initial DW-MRI scan was performed 7 d prior to the start of RT. DW-MRI scans were then taken once weekly during the course of neoadjuvant treatment.

DWI was performed on a 1.5 T magnetic resonance machine (1.5 T Signa Twin Speeder with Excite, GE, United States) using a phased-array body coil. Before DW-MRI, standard T2-weighted fast spin echo sequence and T1-weighted spin echo sequence images were used for clinical staging. DWI echo planar images were ac-

**Table 1 Patients and treatment characteristics**

No.	Age (yr)	Preoperative stage	Surgical treatment	Postoperative stage
1	56	cT3N2M0	LAR	ypT0N1M0
2	57	cT4N2M0	LAR	ypT3N0M0
3	46	cT3N2M0	LAR	ypT3N1M0
4	69	cT4N1M0	APR	ypT2N0M0
5	40	cT3N2M0	APR	ypT3N2M0
6	40	cT3N1M0	APR	ypT0N0M0
7	58	cT4N1M0	APR	ypT2N0M0
8	57	cT3N2M0	APR	ypT0N0M0
9	51	cT4N2M0	Exploratory laparotomy	ypT4N2M0
10	55	cT3N1M0	APR	ypT3N1M0
11	68	cT3N2M0	APR	ypT3N0M0
12	58	cT3N2M0	APR	ypT3N1M0
13	61	cT3N2M0	LAR	ypT1N1M0
14	32	cT4N2M0	APR	ypT3N1M0
15	55	cT3N1M0	APR	ypT3N1M0

LAR: Low anterior resection; APR: Abdominal perineal resection.

quired in the transverse plane using a GRE-EPI sequence (TR/TE 3000/min; field of view 22 cm<sup>2</sup>; matrix size 128 × 128; slice thickness 4 mm; intersection gap 1 mm). DW-MR images and ADC maps were obtained using *b* values of 0 and 1000 s/mm<sup>2</sup> applied in the *x*, *y*, and *z* directions. Patients did not undergo bowel preparation, receive anti-spasmodic medication, or undergo rectal distention before the MR examination. For the image analysis, the data were transferred to a Workstation (AW4.0, GE Medical Systems) and analyzed using the Functool dynamic analysis tool (GE Medical Systems). ADC values were calculated based on the ADC maps. The ADC map of the largest tumor extension in the transverse T2-weighted images was used for the analysis. Regions of interest (ROIs) were drawn manually along the edge of the tumor with a *b* value of 1000 s/mm<sup>2</sup> on the selected ADC maps by an experienced radiologist (Zhang S, with 10 years of experience in clinical MRI), who did not participate in the treatment of the patients or the evaluation of the therapeutic effect.

### Statistical analysis

Statistical analysis was performed using SPSS 12.0 statistical software. Paired comparisons were performed using the Wilcoxon test. Spearman's correlation was used to assess the significance of differences between groups. A *P* value < 0.05 was considered statistically significant.

## RESULTS

### Treatment characteristics

After neoadjuvant treatment, pCR was observed in 2 patients. Downstaging of the tumor was observed in eight patients. The tumor regression grades after neoadjuvant treatment were grade 0-2 in 6 patients and grade 3-4 in 9 patients.

### DW-MRI data

Diffusion data from 15 patients were obtained prior to

and at constant intervals once weekly during the course of neoadjuvant treatment. The observed ADC values are shown in Table 2. A total of 88 ADC values were obtained in our study, and 2 ADC values were excluded due to measurement errors. Sample T2-weighted and diffusion-weighted images prior to treatment are shown in Figure 1. Sample ADC maps from the images taken weekly during the course of neoadjuvant treatment are shown in Figure 2.

The mean tumor ADC value slightly increased from  $0.749 \times 10^{-3}$  mm<sup>2</sup>/s (95%CI:  $0.641 \times 10^{-3}$ - $0.858 \times 10^{-3}$  mm<sup>2</sup>/s) prior to treatment to  $0.772 \times 10^{-3}$  mm<sup>2</sup>/s (95%CI:  $0.627 \times 10^{-3}$ - $0.918 \times 10^{-3}$  mm<sup>2</sup>/s) after the 1<sup>st</sup> week of treatment. There was also a significant increase at the 2<sup>nd</sup> week to  $0.884 \times 10^{-3}$  mm<sup>2</sup>/s (95%CI:  $0.775 \times 10^{-3}$ - $0.994 \times 10^{-3}$  mm<sup>2</sup>/s). Subsequently, the mean ADC decreased to  $0.800 \times 10^{-3}$  mm<sup>2</sup>/s (95%CI:  $0.675 \times 10^{-3}$ - $0.925 \times 10^{-3}$  mm<sup>2</sup>/s) at the 3<sup>rd</sup> week and  $0.766 \times 10^{-3}$  mm<sup>2</sup>/s (95%CI:  $0.659 \times 10^{-3}$ - $0.872 \times 10^{-3}$  mm<sup>2</sup>/s) at the 4<sup>th</sup> week. ADC increased again at the 5<sup>th</sup> week to  $0.839 \times 10^{-3}$  mm<sup>2</sup>/s (95%CI:  $0.702 \times 10^{-3}$ - $0.976 \times 10^{-3}$  mm<sup>2</sup>/s). We also observed a significant increase in the mean ADC value at the 2<sup>nd</sup> (*P* = 0.004) and 5<sup>th</sup> week (*P* = 0.033) during treatment relative to the values prior to treatment. The mean observed ADC values and *P* values are shown in Table 3.

### Tumor ADC for the prediction of treatment response

We compared the tumor ADC values of the responder and non-responder groups to predict the treatment response based on T downstage and TRG criteria.

Downstaging of the tumor was observed for 8 of the 15 patients (53.3%). The ADC values at the 5<sup>th</sup> week during treatment increased for 6/8 patients with T downstaging and increased for 5/7 patients without T downstaging relative to the mean tumor ADC values before treatment. The mean observed ADC values for patients with and without T downstage are shown in Table 4. The difference between these two groups with respect to the mean ADC values measured at the six timepoints did not reach significance.

For the eight patients with tumor downstaging, there was a significant increase (*P* = 0.011) in the mean tumor ADC at the 2<sup>nd</sup> week of treatment relative to the ADC before treatment, whereas for the seven patients without tumor downstaging, there was no significant change in the ADC at any timepoint during treatment relative to the ADC values before treatment (Figure 3A, Table 3).

Good regression (TRG 3-4) was observed in 9 of the 15 patients (60%), and poor regression (TRG 0-2) was observed in 6 patients (40%). The ADC values at the 5<sup>th</sup> week during treatment were increased in 7/9 patients with good regression and 5/6 patients with poor regression relative to the mean tumor ADC values before treatment. The mean observed ADC values in patients with good regression and poor regression are shown in Table 4. Before treatment and at the 3<sup>rd</sup>, 4<sup>th</sup>, and 5<sup>th</sup> week during treatment, significant differences in the mean ADC values between the two groups were obtained.

For the nine patients with good regression, there

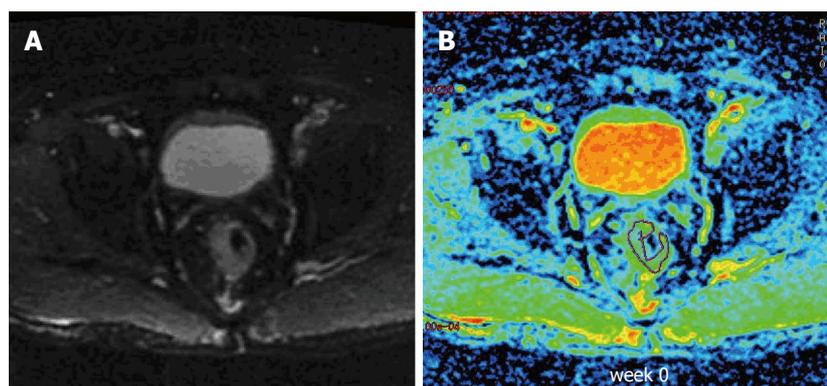
**Table 2** Apparent diffusion coefficient values at six measurement times

No.	Apparent diffusion coefficient values ( $\times 10^{-3} \text{ mm}^2/\text{s}$ )					
	Week 0	Week 1	Week 2	Week 3	Week 4	Week 5
1	0.723	0.743	0.893	0.756	0.606	0.793
2	0.583	0.458	0.786	0.385	0.540	0.793
3	0.752	0.883	0.655	0.711	0.683	0.772
4	0.883	0.887	0.887	0.945	0.923	0.972
5	0.995	0.853	0.995	0.950	0.832	1.120
6	0.813	0.965	1.133	0.964	0.893	0.686
7	0.518	0.416	0.998	0.539	0.527	0.473
8	0.659	0.747	0.825	0.858	0.631	0.746
9	0.814	0.791	0.809	0.894	0.821	0.798
10	0.628	0.637	0.625	0.703	0.784	0.930
11	0.562	0.575	0.806	0.742	0.677	0.515
12	0.616	0.595	0.834	0.850	0.907	1.050
13	0.851	0.825	0.865	- <sup>1</sup>	0.831	0.882
14	0.592	- <sup>1</sup>	0.734	0.622	0.574	0.605
15	1.255	1.435	1.420	1.282	1.256	1.450
95%CI	0.641-0.858	0.627-0.918	0.775-0.994	0.675-0.925	0.659-0.872	0.702-0.976

<sup>1</sup>No data due to measurement error.

**Table 3** Mean tumor apparent diffusion coefficient values and the *P* values for the comparisons with the pretreatment values

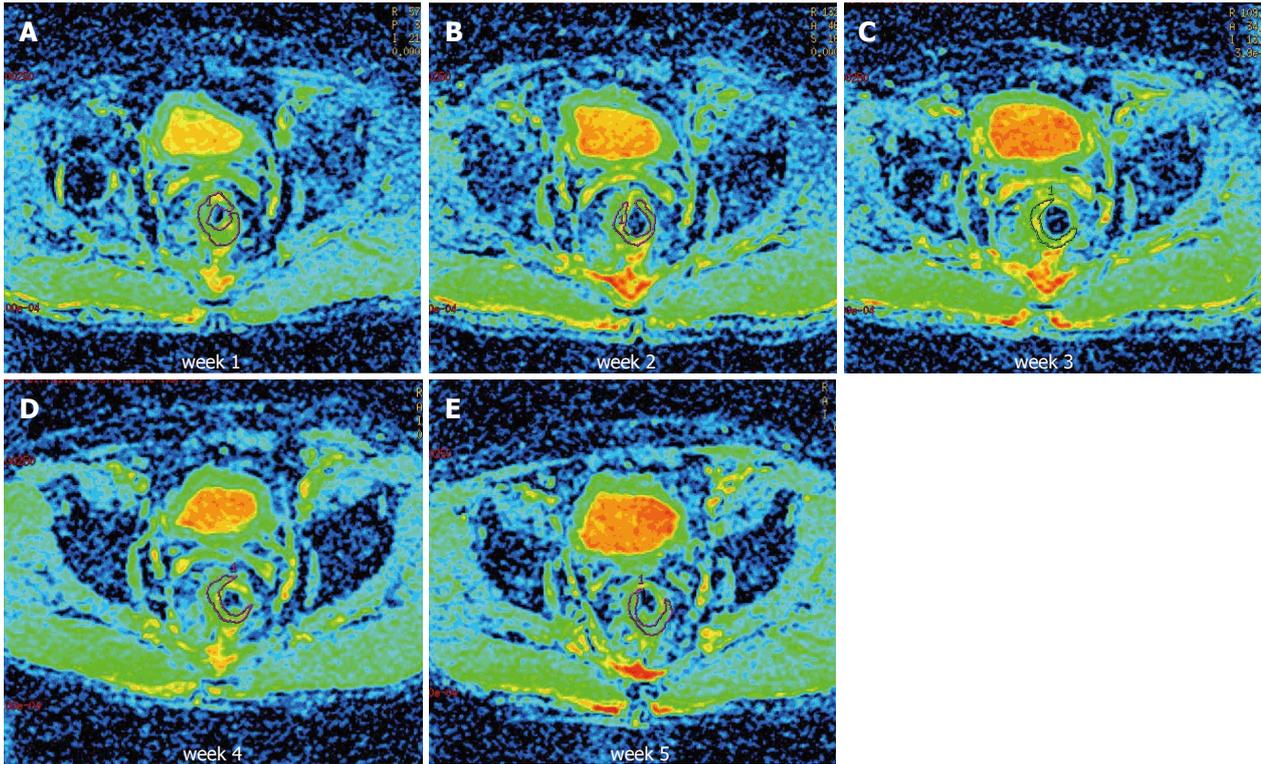
	Apparent diffusion coefficient values ( $\times 10^{-3} \text{ mm}^2/\text{s}$ )					
	Week 0	Week 1	Week 2	Week 3	Week 4	Week 5
All ( <i>n</i> = 15)	0.749	0.772	0.884	0.800	0.766	0.839
<i>P</i> value	-	0.672	0.004	0.077	0.586	0.033
T downstage ( <i>n</i> = 8)	0.703	0.720	0.890	0.724	0.691	0.744
<i>P</i> value	-	0.964	0.011	0.406	0.578	0.284
No T downstage ( <i>n</i> = 7)	0.803	0.824	0.878	0.876	0.851	0.948
<i>P</i> value	-	0.617	0.185	0.117	0.430	0.074
Good regression ( <i>n</i> = 9)	0.659	0.671	0.852	0.696	0.674	0.714
<i>P</i> value	-	0.909	0.004	0.212	0.617	0.251
Poor regression ( <i>n</i> = 6)	0.886	0.907	0.933	0.938	0.904	1.027
<i>P</i> value	-	0.669	0.372	0.264	0.785	0.086



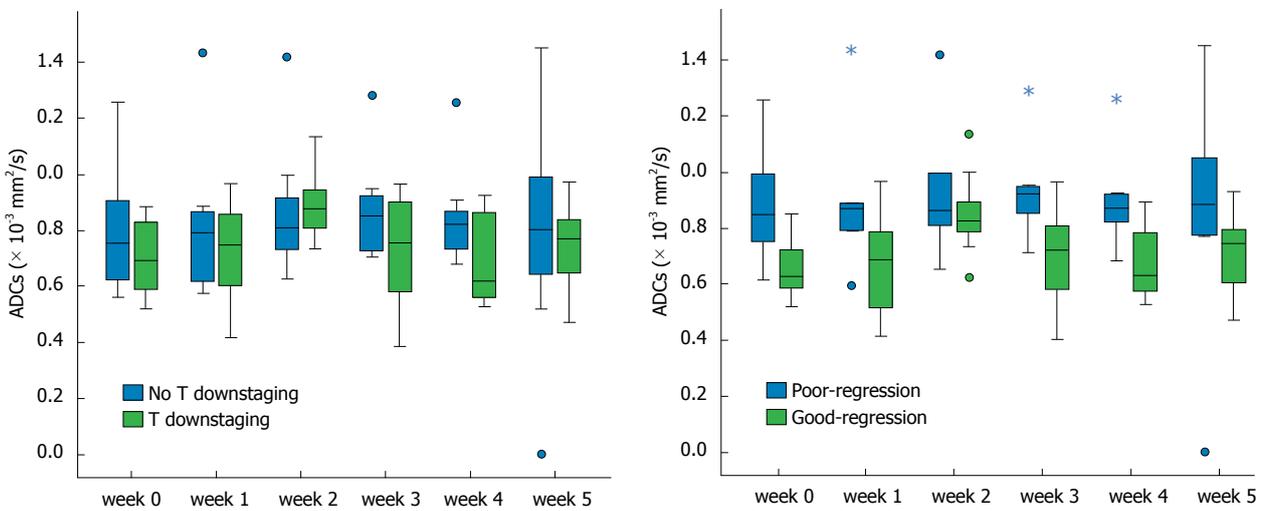
**Figure 1** Sample T2-weighted and diffusion-weighted images from a patient with locally advanced rectal cancer prior to treatment. A: T2-weighted transaxial image through the pelvis prior to treatment; B: Corresponding apparent diffusion coefficient map of the patient obtained from the diffusion-weighted images. A region of interest was drawn around the tumor.

was a significant increase ( $P = 0.004$ ) in the mean tumor ADC value at the 2<sup>nd</sup> week of treatment relative to the ADC values before treatment, whereas for the six patients with poor regression, no significant change in ADC was observed at any timepoint during treatment (Figure

3B, Table 3). The two patients with pCR demonstrated lower ADC ( $0.659 \times 10^{-3} \text{ mm}^2/\text{s}$  and  $0.813 \times 10^{-3} \text{ mm}^2/\text{s}$ ) before treatment but significantly increased tumor ADC ( $0.825 \times 10^{-3} \text{ mm}^2/\text{s}$  and  $1.133 \times 10^{-3} \text{ mm}^2/\text{s}$ ) at the 2<sup>nd</sup> week of treatment.



**Figure 2** Apparent diffusion coefficient maps of one patient obtained at constant intervals once weekly during the course of neoadjuvant treatment from the diffusion-weighted images. A-E: Axial apparent diffusion coefficient maps obtained during treatment (weeks 1-5). A region of interest was drawn around the tumor.



**Figure 3** Mean tumor apparent diffusion coefficient values in patients at six measurement points. A: With and without T downstaging; B: With good regression and poor regression. Cycle: Outlier; Star: Extreme value.

## DISCUSSION

The recent trend toward patient-tailored treatment for LARC has highlighted the need for a reliable method for the early assessment of treatment response. DWI-MRI may be a promising functional imaging tool for the prediction of treatment response. In our study, DW-MRI was investigated as a potential clinical tool to predict or assess the response of rectal tumors to neoadjuvant concurrent CRT at an early timepoint.

Our results show that CRT induced a significant increase in mean tumor ADC in LARC. Because the ADC values obtained from DWI measurements reflect tumor cellularity and anti-tumor treatment decreases tumor cellularity, CRT should increase the ADC value. The administration of CRT results in cell swelling, necrosis, and apoptotic cell death. When CRT is initiated, the ADC may rapidly decrease over several hours due to cell swelling, followed by an increase over several days concurrent with cell death. Increased ADC values have also been

**Table 4 Mean tumor apparent diffusion coefficient values and *P* values for the comparisons between groups**

Group	Apparent diffusion coefficient values ( $\times 10^{-3} \text{ mm}^2/\text{s}$ )					
	Week 0	Week 1	Week 2	Week 3	Week 4	Week 5
T downstage ( $n = 8$ )	0.702	0.720	0.890	0.724	0.690	0.743
No T downstage ( $n = 7$ )	0.803	0.824	0.877	0.875	0.851	0.947
<i>P</i> value	0.339	0.463	0.909	0.202	0.108	0.114
Good regression ( $n = 9$ )	0.658	0.670	0.851	0.618	0.673	0.713
Poor regression ( $n = 6$ )	0.885	0.907	0.933	0.938	0.903	1.027
<i>P</i> value	0.021	0.081	0.452	0.032	0.016	0.010

correlated with tumor necrosis and reduced cell density<sup>[15]</sup>, and most studies have found an increase in ADC after CRT<sup>[12,16,17]</sup>. For example, Kim *et al.*<sup>[12]</sup> recently showed that neoadjuvant CRT caused a significant increase in the ADC values of 76 rectal cancer patients. In contrast, Hein *et al.*<sup>[18]</sup> reported a decrease in the ADC after CRT in all nine of their patients, and they attributed this result to intratumoral radiation-induced fibrosis and cytotoxic edema as well as to the method employed (ROI excluding apparent necrotic areas).

Our results indicate that the mean pre-CRT ADC was negatively correlated with tumor regression ( $P = 0.021$ ) but not with T downstaging ( $P = 0.339$ ). T downstaging and TRG criteria were used because these are common factors used for the evaluation of treatment responses<sup>[19,20]</sup>. The TRG was not completely concordant with T downstaging, and some studies have shown that the pretreatment ADC value is negatively correlated with treatment response in rectal cancer and other tumors<sup>[10,21-25]</sup>. Dzik-Jurasz *et al.*<sup>[10]</sup> found a strong negative correlation between the mean pretreatment tumor water ADC and the percent change in the size of the tumor after chemotherapy and chemoradiation in 2002. ADC values are generally higher for necrotic tumors than for solid or viable tumors<sup>[26]</sup>. Because necrotic areas in tumors are resistant to radiation, it may be hypothesized that tumors with necrotic areas, and thus high pretreatment ADC values, would have less favorable treatment responses. However, other studies have obtained different results; for example, several studies of rectal and other tumors found no correlation between the pretreatment ADC value and treatment response<sup>[11,27,28]</sup>, whereas another study found a positive correlation<sup>[12]</sup>. Several factors may explain these different correlations, such as small sample sizes, the use of different methods for calculating the ADC, and the use of different indicators for the evaluation of treatment response.

A substantial change in the mean ADC value at the 2<sup>nd</sup> week of CRT predicted the tumor response of LARC in our study. Most studies have assumed that CRT decreases tumor cellularity and results in a substantial change in the ADC value<sup>[18,26]</sup>. Although decreasing tumor cellularity will lead to a reduction in tumor size, this reduction is typically observed 3 wk or more after the start of CRT<sup>[29,30]</sup>. Thus, a more rapid evaluation or prediction of treatment response would be clinically useful. We

found a significant increase in the mean ADC at the 2<sup>nd</sup> week in the T downstage ( $P = 0.011$ ) and good regression ( $P = 0.004$ ) groups but not in the groups of patients without T downstaging and with poor regression. We believe that the significant increase in the mean ADC at the 2<sup>nd</sup> week of treatment was correlated with tumor necrosis and apoptosis, which reduce cell density, after the start of therapy. Similar results have been obtained in several other studies. For example, one study examined the ADC data of nine patients with LARC, and a significant change in the mean ADC starting at week 2 of CRT was observed<sup>[18]</sup>. In another study focused on the early detection of responses to CRT in cervical cancer, the changes in the ADC value after 2 wk of therapy were also significantly correlated with the treatment response<sup>[27]</sup>.

There are several limitations of our study. First, the study sample size was small. Second, the sample slice with the largest tumor extension was selected to determine the ADC value, and the use of this slice may not have adequately captured the heterogeneity of the tumor. Third, the ROIs were drawn manually, and this process may have influenced the ADC value and introduced subjectivity. The reason the ROIs were drawn manually by a single experienced radiologist was to obtain more uniform and stable ADC values.

Our study and several previous studies highlight the value of DW-MRI as a predictive tool for the response of rectal cancer to chemoradiation. However, there are some difficulties associated with incorporating DW-MRI into routine clinical practice. The reproducibility of DWI has been insufficiently investigated, and the cut-off values used to determine treatment response vary between treatments and ADC measurement techniques. Thus, a standardized guideline to predict or assess treatment response is needed before DWI can be implemented in clinical practice.

In this study, the tumor ADC values changed during the course of neoadjuvant chemoradiation. The pretreatment tumor ADC value was negatively correlated with tumor regression after chemoradiation for the treatment of LARC, and the ADC value at the 2<sup>nd</sup> week of therapy was significantly correlated with the tumor response. Our results indicate that DW-MRI may be a valuable clinical tool to help predict or assess the responses of rectal tumors to neoadjuvant concurrent chemoradiation at an early timepoint.

## COMMENTS

**Background**

Neoadjuvant (chemo)radiation followed by surgery has become the standard treatment for locally advanced rectal cancer (LARC). However, approximately 20%-30% of patients do not benefit from this neoadjuvant treatment due to radioresistance of the tumor. Functional non-invasive diffusion-weighted magnetic resonance imaging (DW-MRI) studies are increasingly used to predict response to cancer therapy, but definitive evidence is limited, especially for patients with rectal cancer treated with neoadjuvant chemoradiation therapy (CRT).

**Research frontiers**

DW-MRI is a non-invasive functional MRI technique. To date, published data on the value of DW-MRI as a predictive tool for assessing responses to anti-cancer treatment in patients with rectal cancer are scarce and conflicting.

**Innovations and breakthroughs**

The authors found that CRT induced a significant increase in the mean apparent diffusion coefficient (ADC) value of LARC. The pretreatment tumor ADC was negatively correlated with tumor regression after CRT for the treatment of LARC, and the ADC value at the 2<sup>nd</sup> week of therapy was significantly correlated with the tumor response.

**Applications**

The results of this study suggest that DW-MRI may be a valuable clinical tool to help predict or assess the responses of rectal tumors to neoadjuvant concurrent CRT at an early timepoint.

**Terminology**

DW-MRI is a non-invasive functional MRI technique that provides information by measuring water proton mobility in tissues. ADC values can be calculated from DWI measurements according to the impediment to free diffusion of water molecules in a single voxel due to restricting barriers such as membranes, macromolecules, and fibers inside different tissue compartments.

**Peer review**

This is an interesting study that investigates the use of DW-MRI as a predictor of the tumor response in 15 patients with rectal cancer undergoing CRT therapy by measuring the tumor ADC. This is an emerging field in which new knowledge is needed, and this study, despite its limits, provides novel information that may help to settle the current debate about the utility of DW-MRI as a predictive tool for the response to anti-cancer treatment.

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