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PICTORIAL ESSAY

A pictorial review of the impact of adding diffusion-weighted MR imaging to other MR sequences for assessment of anal fistulae

Takeshi Yoshizako · Hajime Kitagaki

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Abstract The purpose of this article was to review the utility of diffusion-weighted MR imaging (DWI) findings in anal fistulae compared to other sequences, and to become familiar with the wide variety of DWI findings of this entity. DWI is useful for evaluating anal fistulae because it makes it possible to detect small lesions and many lesions at the same time, show the spread of the lesions, and assess the degree of inflammation, and it can be useful when following up anal fistulae.

Keywords MRI · Diffusion-weighted MR imaging · Anal fistula

Introduction

Anal fistula and abscess are anorectal disorders with a prevalence of 1 per 10,000 in the general population. The underlying causes include cryptoglandular infection, Crohn's disease, radiotherapy, and secondary malignancy [1]. Although many anal fistulae are easy to treat surgically, some recur despite seemingly adequate operative management. Recurrence is most often due to a focus of infection that has escaped detection by the surgeon.

Therefore, the importance of pretreatment and follow-up imaging to evaluate these conditions is now well recognized. Magnetic resonance (MR) imaging is an accurate technique for the pretreatment detection of fistulae, as well as associated secondary tracts and abscesses. Pretreatment MR imaging data can be employed for surgical planning to reduce the chance of recurrence, and this can alter the outcome for fistula patients [2–4].

Diffusion-weighted MR imaging (DWI) achieves excellent contrast between lesions, such as cancer or an inflammatory focus, and the surrounding tissue. Although DWI of structures outside the brain is mainly employed for oncological applications, evaluation of abscesses could be another important use of this imaging protocol [5–9].

This article is a pictorial review of the impact of adding DWI to other MR sequences for the assessment of anal fistula.

MR technique

All patients were examined with a 1.5-T system (Signa CV/i ver. 9.1, GE Medical Systems, Milwaukee, WI, USA) using a pelvic phased-array coil. Each patient was given an intramuscular injection of hyoscine-*N*-butylbromide (Buscopan, Boehringer Ingelheim, Ingelheim am Rhein, Germany) to minimize artifacts due to peristalsis. No oral or rectal contrast agents were administered.

Fat-suppressed fast spin-echo T2-weighted imaging (T2WI) [repetition time/echo time (TR/TE) 4,000/100 ms; echo-train length, 12] was performed in the true axial plane. Axial fat-suppressed spin-echo T1-weighted images (T1WI) (TR/TE, 863/13 ms) were also acquired at 70 s after the intravenous administration of gadolinium (gadodiamide, 0.1 mmol/kg of body weight; Omniscan, GE Healthcare, Little Chalfont, UK). Other imaging parameters included a slice thickness of 5 mm, an interslice gap of 0.5 mm, a matrix size of 256 × 224, and a field of view (FOV) of 220 mm × 220 mm.

Diffusion-weighted MR imaging was also performed in the true axial plane using a single-shot spin-echo echo-

T. Yoshizako (✉) · H. Kitagaki
Department of Radiology, Shimane University Faculty of Medicine, P.O. Box 00693-8501, 89-1 Enya, Izumo, Japan
e-mail: yosizako@med.shimane-u.ac.jp

planar imaging (SE-EPI) sequence. Imaging parameters included a TR/TE of 4,000/83.7 ms, a flip angle of 90°, a slice thickness of 5 mm, an interslice gap of 0.5 mm, an actual matrix size of 128 × 192 with reconstruction to 256 × 256, an FOV of 420 × 210 mm^2, a bandwidth of 110 kHz, 8 signal averages, and *b* values of 0 and 1,000 s/mm^2. Three orthogonal directions of motion-probing gradients were used.

Detection of small and multiple foci

Hori et al. [8] reported that DWI is a useful sequence that can be a helpful adjunct to T2WI for detection of perianal fistula. On DWI, a fistula appears as a region of high signal intensity, while the background signal is significantly suppressed. Some fistulae can be diagnosed with improved confidence by adding DWI to fat-suppressed T2-weighted imaging (T2WI). DWI can detect small lesions with its high contrast resolution (Fig. 1), and reveals multiple foci with excellent clarity (Fig. 2).

Assessment of the extent

Both the fistula and adjacent tissues show a similar high signal intensity on fat-suppressed T2WI. On the other hand, the fistula displays a high signal intensity on DWI that is easy to distinguish from adjacent structures, and the extent of a fistula can be more clearly visualized (Fig. 3). This is probably due to the higher fistula/background contrast ratio on DWI, which is helpful for detecting these lesions and following the tracts. It is also crucial to evaluate the course of the fistula with respect to adjacent structures for preoperative planning. Therefore, images with a high spatial resolution are required for anatomic orientation (Fig. 4). In this regard, DWI has the disadvantage of inherently poor spatial resolution [8]. Thus, DWI is only useful in

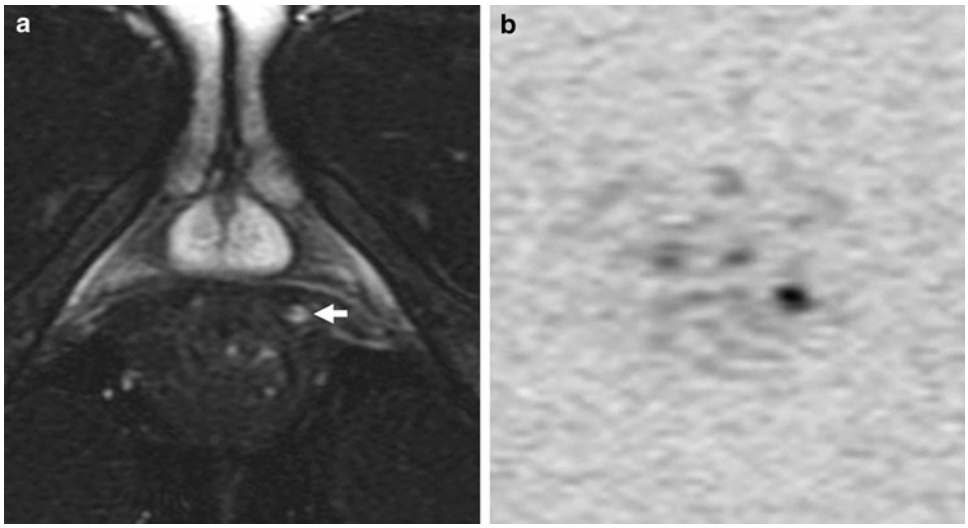

Fig. 1 A 26-year-old man who presented with anal pain. **a** A left-sided anal fistula (*arrow*) shows a spotty high signal intensity on fat-suppressed T2WI. **b** The lesion shows a high signal intensity on DWI that suggests a small region of active inflammation

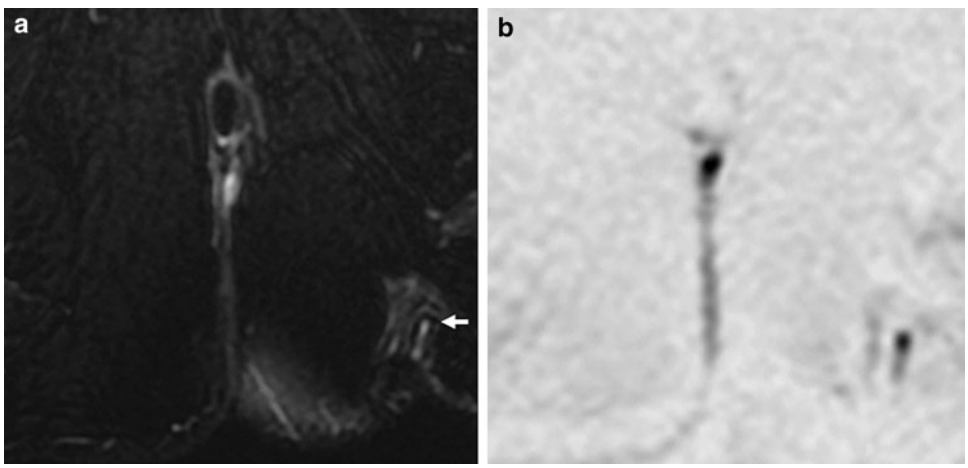

Fig. 2 A 34-year-old man presented with an anal fistula and gluteus abscess due to Crohn's disease. **a** The small anal fistula and gluteus abscess (*arrow*) show a high signal on fat-suppressed T2WI. **b** The fistula and gluteus abscess both have a high signal intensity on DWI. The gluteus abscess is large, while the anal fistula is a relatively small focus. Despite this, it is easy to find due to its high signal intensity on DWI

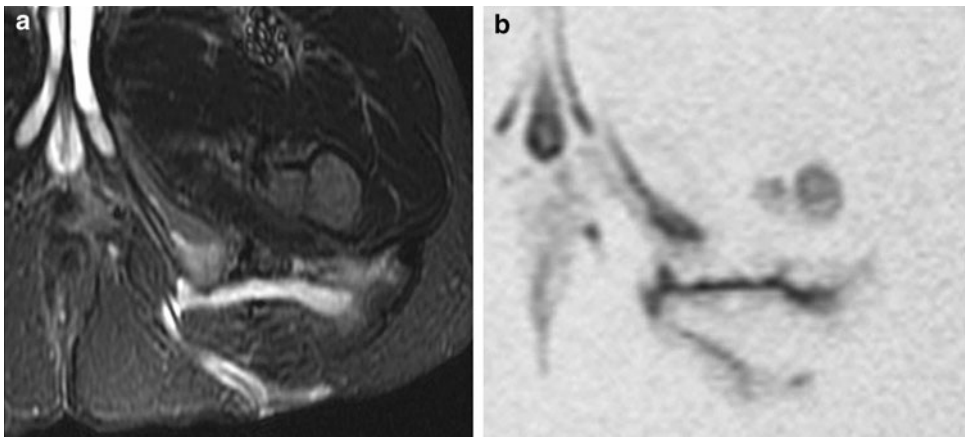

Fig. 3 A 37-year-old man presented with a deep anal abscess. **a** Fat-suppressed T2WI shows that the abscess has spread deeply to involve a large area. **b** DWI shows active inflammation inside a deep and large abscess. DWI can be used to assess inflammatory activity and to easily define the extent of an abscess

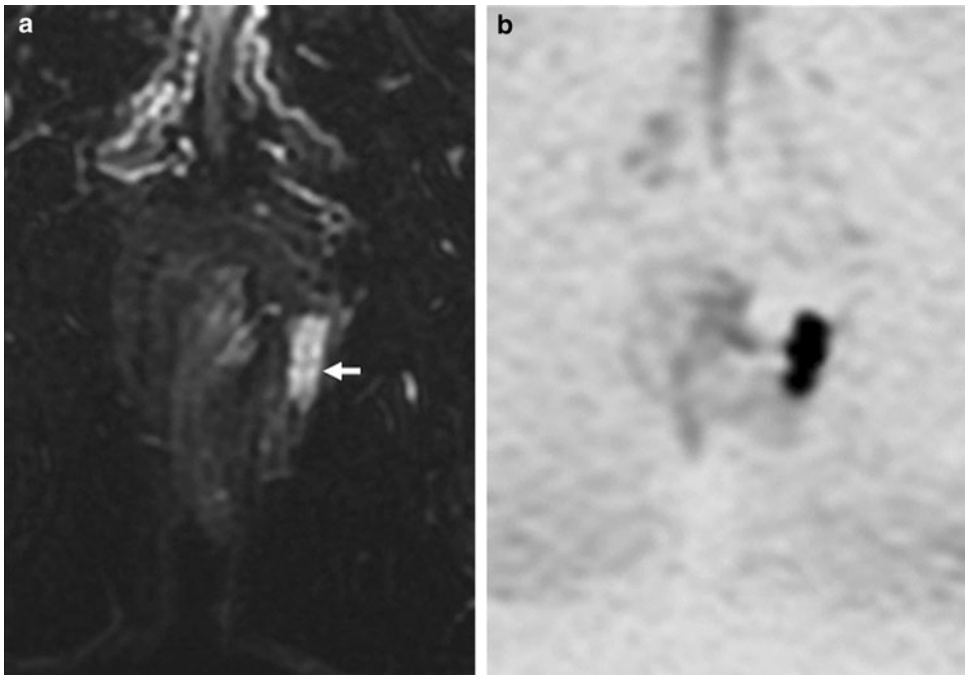

Fig. 4 A 44-year-old woman presented with a left supralevator abscess due to ulcerative colitis. **a** Fat-suppressed T2WI shows a right supralevator abscess as a high signal intensity lesion (*arrow*). **b** DWI shows the high signal intensity abscess, but cannot provide information about the anatomical position. On the other hand, fat-suppressed T2WI can be used to understand the location of the abscess and its relation to the levator ani. Assessing the relation to this muscle is an important task when determining the treatment

conjunction with the more common fat-suppressed T2WI to enhance the identification of fistulous tracts and characterize sites of active inflammation in patients with anal fistula.

Assessment of inflammation

It is still unclear whether DWI can be used to assess disease activity. However, there has been a report [7] that DWI with measurement of ADC may be useful for discriminating active from inactive perianal fistulae. In particular, ADC measurement may be helpful for excluding active inflammation. Yoshizako et al. [7] reported that an optimal cut-off ADC of 1.109×10^{-3} mm^2/s with a 1.5-T MR system using b values of 0 and 1,000 s/mm^2 yielded a sensitivity of 95.7 %, a specificity of 50 %, a positive predictive value of 71 % and a negative predictive value of 90 %.

Active fistulae contain pus and granulation tissue and are therefore seen as high-intensity structures on T2WI [2, 4, 10–13]. Occasionally, a high signal intensity may also be detected in the fibrous tissue, probably reflecting edema [4]. On enhanced T1WI, active granulation tissue is enhanced, while the pus in the fistula shows a low signal intensity [4, 13]. Abscesses contain inflammatory cells, proteins, cellular debris, and bacteria in highly viscous pus [9], and can also exhibit low diffusivity that results in a high signal intensity on DWI. Thus, DWI can be used to evaluate the activity of a perianal fistula [7], since the signal intensity of the lesion will vary with the severity of inflammation (Figs. 5, 6).

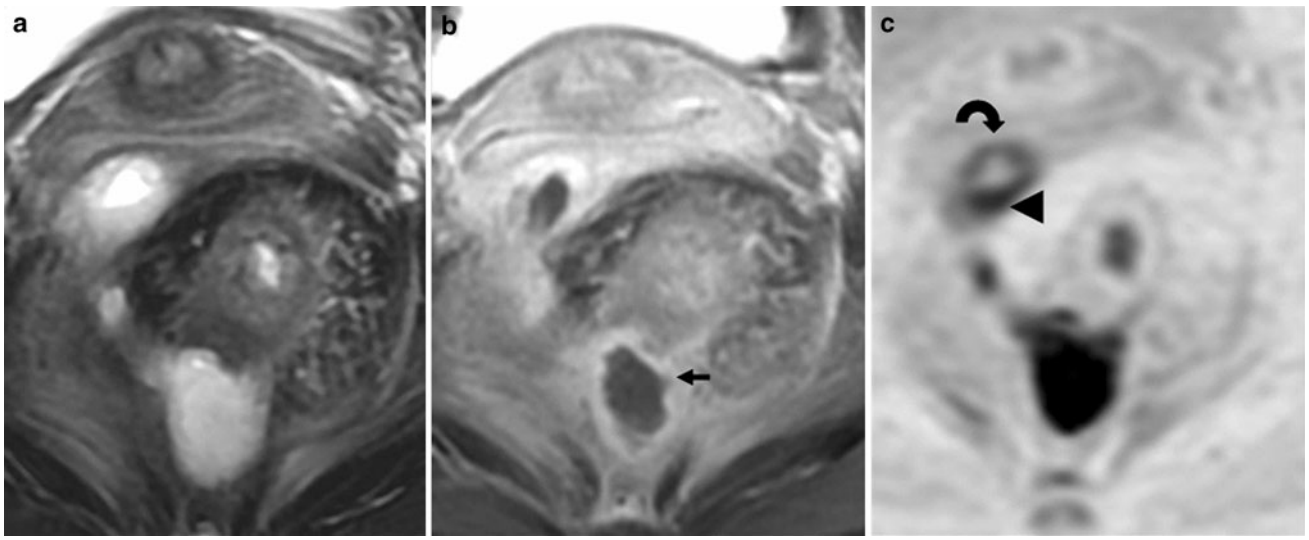

Fig. 5 A 24-year-old woman with a perirectal abscess due to Crohn's disease. **a** Fat-suppressed T2WI shows an abscess with pus fluid and a fistula. **b** Fat-suppressed enhanced T1WI shows enhancement of the abscess wall (*arrow*). **c** DWI reveals a high signal intensity of both the pus and the abscess wall. A cystic mass (*curved arrow*) with a thickened wall lies directly behind the uterus, and inflammation has spread to the right ovary. DWI shows a high signal intensity, indicating active inflammation, in the region of the right ovary (*arrowhead*). DWI is useful for evaluating the spread of inflammation to adjacent organs

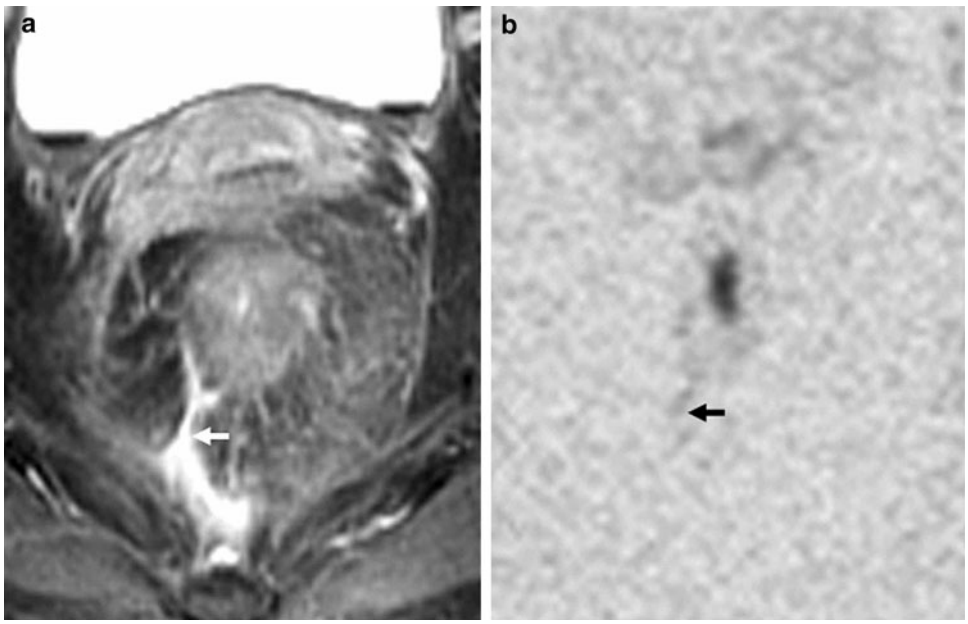

Fig. 6 A 27-year-old woman with an anal scar. **a** Fat-suppressed enhanced T1WI reveals the scar easily (*arrow*). **b** DWI shows no abnormal intensity of the scar (*arrow*). Fat-suppressed enhanced T1WI enhances the granulation tissue, while DWI shows that there is no abnormal intensity and no active inflammatory focus in the scar

On enhanced T1WI, active granulation tissue shows enhancement [4, 13]. The important advantages of DWI over enhanced MR imaging [14] are that a contrast agent is not required, DWI can be readily performed with commercial scanners, and post-processing of data is relatively easy. In addition, DWI allows us to easily visualize the three-dimensional architecture of lesions as it realizes high contrast with the surrounding tissues [8].

MRI for follow-up of anal fistula

Post-inflammatory granulation tissue is seen as a high signal intensity structure on fat-suppressed T2WI [10–13]. On enhanced T1WI, active granulation tissue shows enhancement [4, 13]. It has also been documented that enhanced imaging is sometimes better than non-contrast imaging for depicting the anatomy of a fistula, and this has

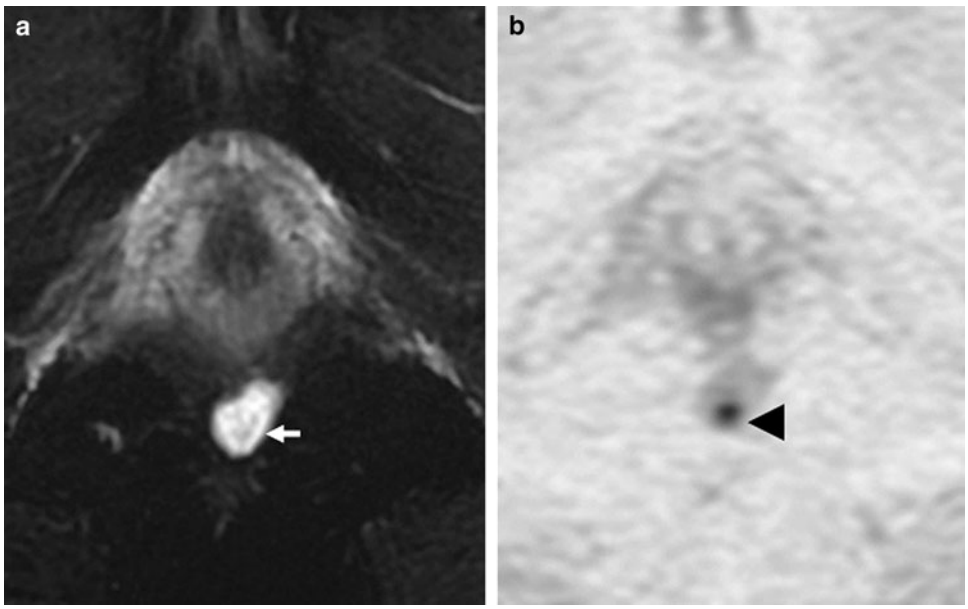

Fig. 7 A 58-year-old man with a perineal abscess after a Miles operation. **a** On fat-suppressed T2WI, the perineal fistula (*arrow*) shows a high signal intensity. **b** On DWI, the lesion displays spotty partial high signal intensity (*arrowhead*) that suggests foci of active inflammation. This patient had undergone rectal resection, so the lesion could not be palpated. DWI revealed abnormal intensity of lesions that could not be palpated

become part of the imaging protocol for fistulae at some institutions [11]. However, the use of a contrast agent leads to increased cost, and may be contraindicated in patients with impaired renal function due to concern about nephrogenic systemic fibrosis (NSF) [15]. On DWI, areas of non-inflammatory granulation tissue are seen as low-intensity structures (Fig. 6).

Diffusion-weighted MR imaging is useful for evaluating disease activity and changes in response to treatment. DWI is also useful for evaluating the extent of active lesions. Moreover, DWI can provide a large amount of information in situations where digital examination cannot, such as after a Miles operation. For example, DWI can detect lesions that cannot be palpated (Fig. 7).

Conclusion

The major benefit of using DWI to evaluate anal fistula is that confidence in the diagnosis can be improved by adding DWI to fat-suppressed T2WI. However, DWI has poor spatial resolution, so high spatial resolution imaging will always be required for anatomic orientation. The impact of adding DWI to other MR sequences to assess anal fistula is that it improves the identification of tracts and foci of active inflammation. DWI is a useful imaging sequence for anal fistula that can be a helpful adjunct to fat-suppressed T2WI, especially in patients with risk factors that contraindicate the use of contrast agents.

Conflict of interest The authors declare that they have no conflict of interest.

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