Ann Med Res 2020;27(10):2763-8

Annals of Medical Research

DOI: 10.5455/annalsmedres.2020.04.301

Original Article

Added value of contrast-enhanced and diffusion-weighted MRI data sets for characterization of perianal fistulas; single center experience

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Abstract

Aim: Our aim in this study is to determine the effectiveness of fat-suppressed T2-weighted (FS-T2W), FS-T2W+Diffusion-weighted image (DWI) and FS-T2W+Contrast-enhanced (CE) magnetic resonance imaging (MRI) data sets in the diagnosis of perianal fistula (PAF).

Material and Methods: Retrospective analysis of 207 patients with a history of PAF operation between January 2018 and March 2020 was performed. The inclusion criteria were patients with PAF who underwent MRI prior to surgery and had a detailed intraoperative report. MRI data sets were evaluated by a radiologist, assessed fistula type, internal/external orifice position and presence of abscess/secondary tracts. The Cohen's kappa (κ) statistic was used to define the level of between from intraoperative findings and MRI data sets agreement. The sensitivity and specificity were compared using the McNemar's test.

Results: All MRI data sets showed the presence of PAF correctly (n = 67, 100%). When the type of PAF per St James and AGA classification, presence of perianal abscesses/secondary tract agreement between intraoperative findings and MRI data sets is evaluated; moderate agreement for isolated FS-T2W data set, almost perfect agreement for combined FS-T2W+DWI and FS-T2W+CE data sets. In the evaluation of agreement for internal/external orifice position; substantial agreement for isolated FS-T2W data set, almost perfect agreement for combined FS-T2W+DWI and FS-T2W+CE data sets. Combined FS-T2W+DWI and FS-T2W+CE data sets have equal sensitivity and specificity each other ($p = 0.544$) and both data sets higher sensitivity and specificity than isolated FS-T2W data set ($p < 0.001$, $p < 0.001$, respectively).

Conclusion: Adding DWI or CE data sets to the FS-T2W data set in the diagnosis of PAF has been shown to detect both diagnosis and complications with high accuracy. Combined FS-T2W+DWI and FS-T2W+CE data sets have equal sensitivity and specificity, and the use of the FS-T2W+DWI data set can prevent unnecessary use of contrast agent.

Keywords: Contrast agent; diffusion-weighted imaging; magnetic resonance imaging; perianal fistula

INTRODUCTION

Perianal fistula (PAF) is defined as the abnormal connection between the mucosal layer of the anal canal-rectum and the perianal skin (1). The average estimated incidence is reported between 0.8-2.3:10000. It generally affects young adults and is more common in men than in women (2). The cryptoglandular infection hypothesis is the most common theory in the etiology of PAF and represents the chronic phase of intramuscular anal gland sepsis. In addition, Crohn's disease, pelvic infections, radiotherapy, diverticulitis, birth trauma and pelvic malignancies have also been reported in etiology (2,3). The most common symptoms are discharge and local pain.

Although most PAF can be easily treated surgically, the rate of recurrence is high. The most important factors associated with relapse development are the inability to clearly define the internal orifice and complex fistulas (4). In order to reduce the possibility of successful surgery and recurrence, it is necessary to define the relationship of the fistula tract with the anal sphincter, the course of the fistula tracts, the possibility of the presence of secondary tract and perianal abscess.

Magnetic resonance imaging (MRI) is the standard imaging technique used for preoperative evaluation and recurrence research in the postoperative period. It has a high accuracy rate especially in patients with complex PAF and Crohn's disease. MRI clearly demonstrates the internal - external orifice, the presence of abscess, secondary tracts and the relation of the fistula tract with the ischioanal / ischiorectal fossa (4,5). MRI sequences containing fat-

Received: 03.04.2020 **Accepted:** 28.09.2020 **Available online:** 22.10.2020
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suppressed T2-weighted turbo spin echo (FS-T2W-TSE) image or fast spin echo (FS-T2W-FSE) image are often sufficient for the diagnosis of PAF. Contrast-enhanced T1-weighted (CE-T1W) images, on the other hand, were added to the MRI fistula protocol, as they both better detect abscess formations and clearly distinguish active-fibrous tracts (6). However, the use of gadolinium-based contrast agents both increases costs and there is a risk of developing nephrogenic systemic fibrosis (NSF) in patients with renal failure (7). Diffusion-weighted image (DWI), on the other hand, is a functional imaging technique based on water movement and providing information about the cellular density and membrane integrity of the tissue (8). Recent studies have reported that DWI is quite effective in detecting PAF and complications (9,10). DWI can be easily added to the routine MRI protocol, as it does not require contrast media, is short in duration, and does not require additional equipment.

Our aim in this study is to determine the effectiveness of FS-T2W, FS-T2W + DWI and FS-T2W + CE data sets in the diagnosis of PAF by using intraoperative findings as a reference and to compare the diagnostic efficacy of the sequences.

MATERIAL and METHODS

This research was conducted in accordance with the 1964 Helsinki Declaration and the requirement for informed consent was waived as this was a retrospective study.

Study Population

A retrospective search of our hospital database for the period between January 2018 and March 2020 was queried to identify patients who underwent surgical operation for the diagnosis of PAF. The inclusion criteria were patients with PAF who underwent MRI prior to surgery and had a detailed intraoperative report. The exclusion criteria were: no available MRI before surgery (n = 54), no available DWI data set (n = 25), no available CE data set (n=22), patients who had negative MRI (n = 14), incomplete operative reports (no defined internal/external orifice position) (n = 14) and patients with poor image quality (n= 11). As a result, 67 patients (57 men vs. 10 women) of 207 were enrolled in the study. The mean age of the study population was 43.49 ± 13.89 years, ranging from 16 to 73 with a median of 28 years.

MRI Acquisitions and Image Interpretation

MRI scans were performed on a 1.5-Tesla scanner (Magnetom Symphony, Siemens Medical Solutions, Erlangen, Germany) by using pelvic phased-array multicoil. MRI protocol for PAF were obtained including following these sequences; (a) oblique axial T2W-FSE image with small field of view (FOV); (b) oblique axial FS-T2W-FSE image with small FOV; (c) oblique axial DWI using including b-value 0-500-1000 s/mm^2; (d) oblique coronal FS-T2W-FSE image, oriented orthogonal and parallel to anal canal long axis; and (e) axial and (f) coronal CE-T1WFS using gadoterate meglumine (Dotarem, Guerbet, Paris, France). ADC values were calculated automatically using a mono exponential fitting algorithm.

MRI of each patient were retrospectively evulated by a board-certified radiologist (SA, 8 th years of experience) using a PACS workstation. The radiologist was aware of the suspected of PAF of the patients, but blinded to the intraoperative findings and reports. The radiologist separately evaluated three imaging data sets: (1) isolated FS-T2W data set; (2) combined FS-T2W + DWI data set; and (3) combined FS-T2W + CE data set. For each MRI data set, were recorded fistula type according to St James's classification and AGA classification, also noted internal-external orifice, presence of perianal abscess and presence of secondary tracts.

Intraoperative Findings

Intraoperative findings were used as the reference standard for the presence of PAF. In the intraoperative reports, internal-external orifice, presence of abscess, presence of secondary tracts and fistula type were specified in detail according to St James's classification. The internal and external orifice was considered as correctly depicted when they were at the correct level in the anal canal and within the correct quadrant. Simple and complex fistulas were classified according to the AGA classification.

Statistical Analysis

Normal distribution of the continuous data was assessed using Shapiro-Wilk test and normally distributed continuous data was presented as mean ± standard deviation (SD) as appropriate. Non-parametric data was presented as numbers of cases and percentages. The Cohen's kappa (κ) statistic was used to define the level of between from intraoperative findings and MRI data sets agreement. The scale used for interpretation of weighted κ statistics was: slight agreement 0–0.20; fair agreement 0.21–0.40; moderate agreement 0.41–0.60; substantial agreement 0.61–0.80; and almost perfect agreement 0.81–1.00.

Sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) for isolated FS-T2W data set, combined FS-T2W + DWI data set and combined FS-T2W + CE data set were calculated for the simple/complex fistula, abscess and secondary tracts. The sensitivity and specificity of the MRI data sets were compared using the McNemar's test. Statistical analysis was conducted with Statistical Package for Social Sciences 25.0 (SPSS Inc., Chicago, IL, USA) for MacOS software program. A p value less than 0.05 was indicative of statistical significance.

RESULTS

Patients with included in the study group; demographic data, PAF evaluations according to St James and AGA classification, presence of inflammatory bowel disease, internal and external orifices of PAF, presence of perianal abscess and presence of secondary tract distribution are displayed in Table 1. The most common type of PAF was grade IV (n = 31, 46.3%) (Figure 1) followed by grade III (n = 12, 17.9%) (Figure 2), grade I (n = 11, 16.4%) (Figure 3), grade II (n = 10, 10.4%) (Figure 4), and grade V (n = 3, 4.5%) (Figure 5). Thirty-eight patients (56.7%) had complex fistulas according to the AGA classification.

Table 1. Baseline characteristics of the study population	
Demographics	
Age (mean ± SD)	43.49 ± 13.89
Gender	
Male	57 (85.1)
Female	10 (14.9)
Chron disease	
Ulseratif colitis	
Type of PAF per St James classification for intraoperative findings	
Grade I	11 (16.4)
Grade II	10 (14.9)
Grade III	12 (17.9)
Grade IV	31 (46.3)
Grade V	3 (4.5)
Type of PAF per AGA classification for intraoperative findings	
Simplex	29 (43.3)
Complex	38 (56.7)
Internal – external orifice position[a]	
1	7 (10.4) – 2 (3)
2	3 (4.5) – 3 (4.5)
3	8 (11.9) – 2 (3)
4	7 (10.4) – 1 (1.5)
5	3 (4.5) – 5 (7)
6	21 (31.3) – 37 (55.2)
7	4 (6) – 6 (9)
8	4 (6) – 6 (9)
9	0 (0) – 4 (6)
10	4 (6) – 0 (0)
11	4 (6) – 1 (1.5)
12	6 (9) – 3 (4.5)
Perianal abscesses for intraoperative findings	38 (56.7)
Secondary tracts for intraoperative findings	35 (52.2)

Values are expressed as n (%) unless otherwise noted
SD, standard deviation; [a] The numbers represent the clockwise direction

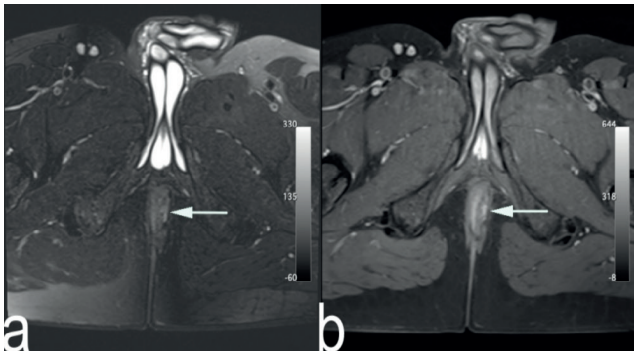

Figure 1. An intersphincteric PAF (grade I) in a 35-year-old man. Axial FS-T2W data set (a), axial CE-T1W data set (b) showed an intersphincteric fistula on the intersphincteric space (arrow)

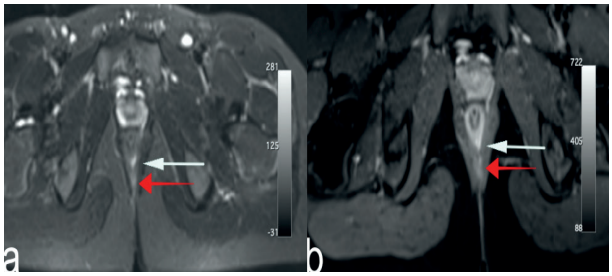

Figure 2. An intersphincteric perianal fistula with abscess (grade II) in a 23-year-old man. Axial FS-T2W data set (a), axial CE-T1W data set (b) showed an intersphincteric fistula on the intersphincteric space (white arrows) with a small intersphincteric abscess (red arrows)

Table 2. Agreement between intraoperative findings and each MRI data sets for the detection of the perianal fistula and its complications			
	Isolated FS-T2W	**FS-T2W + DWI**	**FS-T2W + CE**
Type of PAF per St James classification	0.56	1.00	1.00
Type of PAF per AGA classification	0.43	1.00	1.00
Internal orifice position	0.77	0.95	1.00
External orifice position	0.79	0.96	1.00
Perianal abscesses	0.41	1.00	1.00
Secondary tracts	0.56	1.00	1.00

Values are expressed as weighted kappa

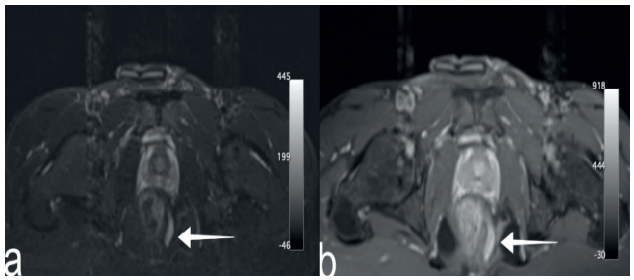

Figure 3. A transphincteric PAF (grade III) in a 24-year-old man. Axial FS-T2W data set (a), axial CE-T1W data set (b) showed involvement of left sided external sphincter (arrow)

The most common internal orifice was 6 o'clock clockwise direction (n = 21, 31.3%) and the most common external orifice was 6 o'clock clockwise direction (n = 37, 55.2%). Thirty-eight (56.7%) patients had perianal abscess and 35 (52.2%) patients had secondary tracts.

When intraoperative findings are used as a reference, all MRI data sets (isolated FS-T2W, combined FS-T2W + DWI and FS-T2W + CE) showed the presence of PAF correctly (n = 67, 100%). When the type of PAF per St James and

AGA classification, presence of perianal abscesses and presence of secondary tract agreement between intraoperative findings and MRI data sets is evaluated; moderate agreement for isolated FS-T2W data set, almost perfect agreement for combined FS-T2W + DWI and FS-T2W + CE data sets. In the evaluation of agreement for internal and external orifice position; substantial agreement for isolated FS-T2W data set, almost perfect agreement for combined FS-T2W + DWI and FS-T2W + CE data sets (Table 2). The addition of DWI or CE data sets to the FS-T2W data set significantly increased agreement with intraoperative findings in showing type of PAF per St James and AGA classification, presence of perianal abscesses, presence of secondary tract and internal-external orifice position.

Table 3. Diagnostic efficacy in detection simple/complex PAF, perianal abscesses, and secondary tracts in each MRI data sets

MRI findings	Isolated FS-T2W	FS-T2W + DWI	FS-T2W + CE
Simple/complex PAF			
Sensitivity	47.4 (38-79.3)	100 (56.7-100)	100 (56.7-100)
Specificity	100 (66.8-100)	100 (66.8-100)	100 (66.8-100)
PPV	100 (46.4-100)	100 (46.4-100)	100 (46.4-100)
NPV	59.2 (43.3-100)	100 (56.7-100)	100 (56.7-100)
Perianal abscesses			
Sensitivity	44.7 (42-87.2)	100 (56.3-100)	100 (56.3-100)
Specificity	100 (76.7-100)	100 (76.7-100)	100 (76.7-100)
PPV	100 (62.4-100)	100 (62.4-100)	100 (62.4-100)
NPV	58 (53-86.7)	100 (58.2-100)	100 (58.2-100)
Secondary tracts			
Sensitivity	57.1 (52.2-98.7)	100 (65.7-100)	100 (65.7-100)
Specificity	100 (88.4-100)	100 (88.4-100)	100 (88.4-100)
PPV	100 (79.2-100)	100 (79.2-100)	100 (79.2-100)
NPV	68.1 (48.9-88.6)	100 (82.6-100)	100 (82.6-100)

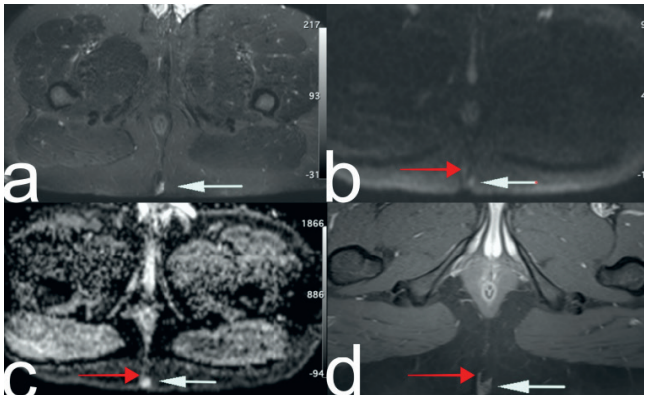

Figure 4. A transsphincteric PAF with abscess (grade IV) in a 43-year-old man. Axial FS-T2W data set (a), axial DWI (b value of 1000 s/mm2) data set (b), axial ADC maps (c), and axial CE-T1W data set (d) showed a transsphincteric fistula (red arrows) with a small transsphincteric abscess (white arrows)

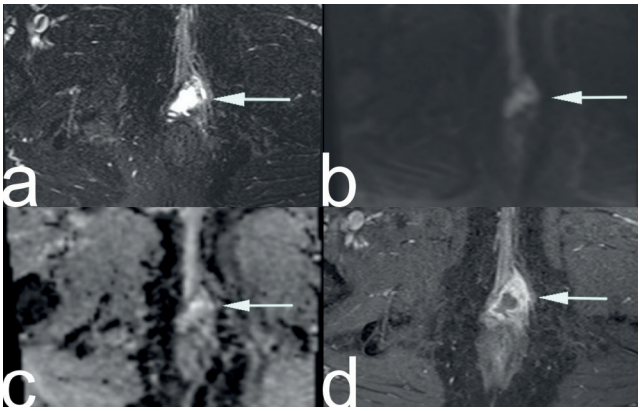

Figure 5. A supralevatoric extended PAF with abscess (grade V) in a 51-year-old man. Axial FS-T2W data set (a), axial DWI (b-value of 1000 s/mm2) data set (b), axial ADC maps (c), and axial CE-T1W data set (d) showed a fistula tract with internal opening at rectum, penetrated levator ani muscle to the skin (arrow)

Table 4. Comparing the sensitivity and specificity of MRI datasets for PAF using the McNemar test

	p value
Isolated FS-T2W vs. FS-T2W + DWI	< 0.001
Isolated FS-T2W vs. FS-T2W + CE	< 0.001
FS-T2W + DWI vs. FS-T2W + CE	0.544

Sensitivity, specificity, PPV and NPV were calculated for iFS-T2W, combined FS-T2W + DWI and FS-T2W + CE. Regarding AGA classification, the isolated FS-T2W data set showed a 47.4% sensitivity, 100% specificity, 100% PPV, and 59.1% NPV in classified simple/complex fistulas. The combined FS-T2W + DWI and FS-T2 + CE data sets had similar sensitivity (100% vs. 100%), specificity (100% vs. 100%), PPV (100% vs. 100%), and NPV (100% vs. 100%). In terms of detection of perianal abscess and secondary tract, the isolated FS-T2W data set had showed a 44.7% vs. 57.1% sensitivity, 100% vs. 100% specificity, 100% vs. 100% PPV, 58% vs. 68.1% NPV. The combined FS-T2W + DWI and FS-T2 + CE data sets had similar sensitivity (100% vs. 100%), specificity (100% vs. 100%), PPV (100% vs. 100%), and NPV (100% vs. 100%). The sensitivity and the specificity of the combined FS-T2W + DWI and FS-T2W + CE data sets were statistically higher than that of isolated FS-T2W data set ($p < 0.001$ and $p < 0.001$, respectively). The sensitivity and the specificity of the combined FS-T2W + DWI data sets was not statistically different than that of combined FS-T2W + CE data sets ($p = 0.544$) (Table 4).

DISCUSSION

Our study demonstrated that the combined FS-T2W + DWI and FS-T2W + CE data sets have equal sensitivity and specificity each other ($p = 0.544$) and both data sets higher sensitivity and specificity than isolated FS-T2W data set ($p < 0.001$, $p < 0.001$, respectively).

Various classification systems are available for PAF. In 1976, described by Parks et al. the first classification made by is an anatomical classification and has been widely used in surgical operations (3). This classification is divided into four groups by accepting the external sphincter reference point. In the intersphincteric fistula, the tract passes through the internal sphincter and is limited to the intersphincteric space, while in the transsphincteric fistula, the tract opens to the skin by crossing both the internal and external sphincter. In the extrasphincteric fistula, the tract penetrates the levator ani muscle before opening to the skin. In the suprasphincteric fistula, the internal orifice is in the rectum, and the tract penetrates the levator ani muscle before opening to the skin. The classification defined by St James's University Hospital in 2000 is based on MR imaging and 5 separate classes are defined; grade 1 = simple linear intersphincteric; grade 2 = intersphincteric with abscess or secondary tract; grade 3 = transsphincteric; grade 4 = transsphincteric with abscess or secondary tract in the ischiorectal/

ischioanal fossa; grade 5 = translevatoric and / or supralevatoric extended fistula (11). The most commonly used classification in clinical practice is the classification proposed by the American Gastroenterology Association (AGA), which separates fistulas into simple and complex (12).

MRI has become the imaging of choice for preoperative evaluation of PAFs due to its ability to demonstrate the hidden areas of infection, internal - external orifice position, and secondary tracts which contribute to postsurgical recurrence and define the anatomic relationships of the fistula (6,11). In the evaluation of PAF, sequences obtained with the use of intravenous gadolinium-based contrast agents have been included in the MRI protocol in many institutes, as it provides the opportunity to show inflammatory tracts and abscesses better (8,11). However, the use of gadolinium-based contrast agent prolongs MRI examination time, causing extra cost and accumulation of gadolinium contrast in the brain, and is also contraindicated for patients with kidney failure, since there is a risk of developing NSF. DWI is a functional imaging technique that provides information about the cellular density of tissue, inflammatory tissues can also exhibit a low diffusivity and can be seen as high signal areas. No contrast agent administration is required. In literature, Cavusoglu et al. and Hori et al. also showed that the confidence scores for the diagnosis of PAF of the combined FS-T2 + DWI data sets or/and FS-T2 + CE data sets were greater than isolated FS-T2 data set (11, 13). In our study, intraoperative findings were taken as reference and according to St James and AGA classification, moderate agreement was found for isolated FS-T2W data set (κ = 0.56, 0.43, respectively), and almost perfect agreement was found for both combined FS-T2W + DWI and FS-T2W + CE data sets (κ = 1.00, 1.00 – 1.00, 1.00, respectively). In addition, while the sensitivity and NPV of the isolated FS-T2W data set is lower than the combined FS-T2W + DWI and FS-T2W + CE data sets (47.4%, 59.2% - 100%, 100% - 100%, 100%, respectively), specificity and PPV were similar (100%, 100% - 100%, 100% - 100%, 100%, respectively). Our results were similar to those in the literature.

In the isolated FS-T2W datasets, the fistula, the internal and external orifice position, and the surrounding soft tissue may show similar hyperintense signals. However, DWI data set show a hyperintense signal and can be easily distinguished from the surrounding soft tissue. This is attributed to the fact that the fistula / background contrast ratio is high on DWI data set. For this reason, it is recommended to use the FS-T2W data set together with the DWI data set in fistula imaging (11). In our study, when in terms of internal and external orifice position, intraoperative findings are taken as reference again, the substantial agreement for the isolated FS-T2W data set (κ = 0.56, 0.43, respectively), and almost perfect agreement for the combined FS-T2W + DWI and FS-T2W + CE data sets (κ = 0.95, 0.96 - 1.00, 1.00, respectively) was found. Also, in our study, it was observed that the combined FS-T2W + DWI data set in 64 patients and the FS-T2W + CE data set in all patients correctly identified the internal and external orifice position. Cattapan et. al. showed that all MRI datasets (isolated T2, combined T2-DWI, and postcontrast) accurately identified internal and external orifice position in their study (14). Hori et al. reported that DWI improved the visualization of the external or internal orifice position in 25% of the cases compared to isolated T2W data set (11). Our results were similar to those reported in the literature.

Our study showed that, in terms of detecting of the perianal abscesses and secondary tracts, when using intraoperative findings as a reference, moderate agreement for isolated FS-T2W data set (κ = 0.41, 0.56, respectively), and almost perfect agreement for combined FS-T2W + DWI and FS-T2W + CE data sets (κ = 1.00, 1.00 – 1.00, 1.00, respectively). Our findings suggest that adding DWI to the FS-T2W data set will not make a difference in diagnosis and is as useful as contrast series, while avoiding the use of contrast agent in detecting perianal abscesses and secondary tracts. Singh et al. also revealed that combined FS-T2W + DWI data sets had high sensitivity, specificity, PPV, and NPV in the detection of secondary fistulous tracts (15). Our results are similar to the data in the literature.

Our study had several limitations. First, the study was designed retrospectively. Second, we included study population who had surgery which can cause selection bias. Third, intraoperative findings have been used as a reference, but it should be borne in mind that surgery may miss some fistulas. Forth, MRI data sets were evaluated by one experienced radiologists. Interobserver consistency was not evaluated.

CONCLUSION

As a result, adding DWI or CE data sets to the isolated FS-T2W data set in the diagnosis of PAF has been shown to detect both diagnosis and complications with high accuracy. In addition, the combined FS-T2W + DWI and FS-

T2W + CE data sets have equal sensitivity and specificity, and the use of the combined FS-T2W + DWI data set can prevent unnecessary use of contrast agent and prevent both cost and contrast-related complications.

Competing interests: The authors declare that they have no competing interest.

Financial Disclosure: There are no financial supports.

Ethical approval: The study was approved by the Giresun University Clinical Research Ethics Committee (No:2020/34).

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