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MRI Anterograde Fistulography Using Rectally Administered Diluted Gadolinium and 3D LAVA-Flex for Preoperative Evaluation of Anal Fistulas: A Prospective Pilot Study

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Research Article

Keywords: anal fistula, magnetic resonance imaging, MRI anterograde fistulography, 3D LAVA-Flex

Posted Date: November 25th, 2026

DOI: https://doi.org/10.21203/rs.3.rs-11743990/v1

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Additional Declarations: No competing interests reported.

Abstract

Background

Accurate preoperative delineation of internal openings and fistulous tracts is important for planning surgery for anal fistulas. MRI anterograde fistulography (MRI-AFG) combines rectally administered diluted gadolinium, a straining defecation, and three-dimensional liver acquisition with volume acceleration-Flex (3D LAVA-Flex) imaging.

Objective

To describe the feasibility and preliminary diagnostic performance of MRI-AFG in the preoperative assessment of anal fistulas.

Methods

In this prospective pilot study, 12 patients underwent conventional MRI and MRI-AFG before surgery in 2026. Surgical findings were the reference standard. Internal openings, fistulous tracts, and Parks classifications were assessed descriptively.

Results

All 12 patients underwent surgery. Surgery identified 20 internal openings and 28 fistulous tracts. Conventional MRI and MRI-AFG detected 16/20 (80%) and 15/20 (75%) internal openings and 25/28 (89.3%) and 21/28 (75.0%) fistulous tracts, respectively. Correct clock-face position and anal-verge distance were each reported for 11/20 (55%) internal openings on conventional MRI and 15/20 (75%) on MRI-AFG. Both methods agreed with the surgical Parks classification in 11/12 patients (91.7%). MRI-AFG maximum-intensity-projection (MIP) images depicted communications among complex fistulous tracts.

Conclusion

MRI-AFG may provide complementary information about patent internal openings and tract communications, although conventional MRI detected more openings and tracts in this small cohort.

Clinical Impact:

MRI-AFG may improve preoperative anatomic mapping in selected patients with complex anal fistulas; larger studies are needed to establish its clinical value.

Introduction

An anal fistula is a relatively common anorectal condition characterized by a granulation tissue-lined tract connecting the anal canal to the perianal skin [1]. Symptoms such as anal discomfort, pruritus, purulent or bloody discharge, and occasional difficulty with defecation can substantially impair patients' quality of life [2].

Anal fistulas often have complex anatomy involving the anal sphincter complex. Treatment aims to eradicate the fistulous tract, primarily through surgery, while preserving continence [1, 3]. Reported risk factors for recurrence include an undetected internal opening, a higher internal opening (i.e., a greater distance from the anal verge), horseshoe extension, and multiple fistulous tracts, particularly in complex disease [2, 4]. Therefore, accurate and comprehensive preoperative delineation of internal openings and fistulous tracts is essential for surgical planning and may help reduce recurrence.

Magnetic resonance imaging (MRI) is widely recognized as an essential modality for the preoperative assessment and management of perianal fistulas [5, 6]. Common conventional MRI sequences include T2-weighted imaging (T2WI), with and without fat suppression (FS), and T1-weighted imaging (T1WI) [7]. However, the relatively large slice thickness of conventional sequences can limit visualization of small internal openings and fine secondary tracts [8]. MR fistulography techniques include direct fistulography with percutaneous instillation of contrast medium [9–11], and indirect fistulography with intravenous contrast-enhanced fat-suppressed T1-weighted imaging [8, 12]. Traditional retrograde percutaneous fistulography relies on injection through an external opening and may be difficult in patients with small or multiple external openings or blind-ending tracts; it can also cause discomfort [13]. Intravenous contrast-enhanced MRI may be unsuitable for some patients with renal impairment. Moreover, adjacent vascular structures can mimic fistulous tracts, whereas chronic fibrotic tracts may show spurious enhancement on contrast-enhanced MRI [11, 12].

Fat-suppressed three-dimensional Liver Acquisition with Volume Acceleration-Flex (3D LAVA-Flex) provides high-resolution isotropic images that can be reconstructed in multiple planes [14]. There are few studies in the literature evaluating use of 3D sequences in the setting of anal fistula.

This study aimed to describe and preliminarily evaluate gadolinium-based MRI anterograde fistulography (MRI-AFG) using a 3D LAVA-Flex sequence for visualization of internal openings and fistulous tracts.

Methods

This prospective study was approved by an institutional ethics committee (approval no. 2024-JS-178), and all patients provided written informed consent. A total of 12 patients were enrolled in the study. The inclusion criteria were (1) a clinical diagnosis of anal fistula; (2) conventional MRI and 3D LAVA-Flex-based MRI-AFG performed within 7 days before surgery; and (3) willingness to undergo surgical treatment. The exclusion criteria were refusal of surgery, anal or rectal tumors, or contraindications to MRI, including metallic implants or foreign bodies in the scan region, claustrophobia, and pregnancy.

MRI techniques

Patients underwent bowel preparation with an enema 3 h before MRI. Preoperative MRI was performed using a 3.0-T scanner (GE, Boston, MA, USA) and a dedicated 32-channel body-array coil.

Each patient first underwent conventional MRI, including axial T2WI with and without fat suppression, sagittal and coronal FS-T2WI, and axial T1WI.

Each patient then received 500 mL of diluted gadolinium-based contrast medium rectally (Gd-DTPA diluted 1:250 in saline). The Gd-DTPA preparation was manufactured by Jiangsu Hengrui Pharmaceuticals Co., Ltd. (15 mL containing 5.654 g). Patients wore disposable diapers and lay supine with their legs extended; the scanner isocenter was aligned with the pubic symphysis. Patients were then instructed to strain as if defecating, allowing contrast medium in the rectum and anal canal to enter any patent fistulous tract (Fig. 1). A 3D LAVA-Flex acquisition was then performed. The 3D LAVA-Flex acquisition parameters are listed in Table 1. No procedure-related adverse events or clinically significant intolerance were observed during or after MRI-AFG.

Table 1
Acquisition parameters for the 3D LAVA-Flex sequence

Parameter	**3D LAVA-Flex**
TR (ms)	5.6
TE (ms)	2.3
Slice thickness (mm)	1.6
Slice gap (mm)	1
Number of slices	80
NEX	2
FOV (mm)	300×300
Acceleration factor	1.5
Flip angle (°)	12
Matrix size	256×256
Bandwidth (Hz/Px)	142.86

3D LAVA-Flex three-dimensional liver acquisition with volume acceleration-Flex, *TR* repetition time, *TE* echo time, *NEX* number of excitations, *FOV* field of view.

Image analysis

Image analysis followed a blinded reading protocol. Two radiologists with 5 and 10 years of experience, respectively, in interpreting MRI of anal fistulas evaluated the images. For conventional MRI and MRI-AFG, the readers recorded the SPTF and Parks classifications; the number and clock-face position of internal openings; the distance from each internal opening to the anal verge; the numbers of primary and secondary fistulous tracts; and the number of horseshoe extensions. Concordant assessments were accepted. Disagreements were adjudicated by a third senior physician, and a consensus decision was reached by all three readers. The Parks classification comprises intersphincteric, transsphincteric, suprasphincteric, and extrasphincteric fistulas [9]. Using surgery as the reference standard, an MRI measurement was considered correct when the absolute difference from the intraoperative measurement was within 5 mm. The position of each internal opening was recorded using clock-face notation. All MRI findings were compared with the surgical findings.

Statistical analysis

Given the exploratory nature of this prospective pilot study and the small sample size, statistical analyses were primarily descriptive. Continuous variables were summarized as means and standard deviations, and categorical variables as frequencies and percentages. Exact 95% confidence intervals were calculated for selected diagnostic proportions. The diagnostic performance of conventional MRI and MRI-AFG was descriptively evaluated using surgical findings as the reference standard.

Results

The study included 12 patients with anal fistulas: 10 men (83.3%) and 2 women (16.7%). The mean age was 44.1 years (SD, 11.2 years; range, 23–61 years).

All 12 patients underwent surgery. Surgery identified 20 internal openings: 6 patients had one opening, 4 had two openings, and 2 had more than two openings. Surgery also identified 28 fistulous tracts: 19 primary tracts, 8 secondary tracts, and 1 horseshoe fistula. According to the SPTF classification, 5 patients had simple and 7 had complex anal fistulas, including 1 horseshoe fistula. According to the Parks classification, 7 patients had intersphincteric, 4 had transsphincteric, and 1 had extrasphincteric fistulas.

Visibility of internal opening

Of the 20 internal openings identified at surgery, conventional MRI detected 16 (80%) and MRI-AFG detected 15 (75%) (Table 2). Although conventional MRI detected slightly more internal openings overall, MRI-AFG provided a more complete depiction in one patient with a complex anal fistula. This patient had two internal openings and two fistulous tracts; conventional MRI depicted only one opening and one tract, whereas MRI-AFG depicted both openings and both tracts (Fig. 2).

Table 2
Diagnostic findings on conventional MRI and MRI-AFG compared with surgery

Number of detectable internal openings	**Conventional MRI**	**MRI-AFG**	**95% CI (conventional MRI / MRI-AFG)**
	16/20 (80%)	**15/20 (75%)**	**(56.3, 94.3)/(50.9, 91.3)**
Position of internal opening	11/20 (55%)	15/20(75%)	(31.5, 76.9)/(50.9, 91.3)
Internal opening (distance)	11/20 (55%)	15/20(75%)	(31.5, 76.9)/(50.9, 91.3)
Number of fistulas	25/28 (89.3%)	21/28 (75%)	(71.8, 97.7)/(55.1, 89.3)
Parks' classification	11/12 (91.7%)	11/12 (91.7%)	(61.5, 99.8)/(61.5, 99.8)
Conventional MRI and MRI-AFG were compared using surgical findings as the reference standard.			
12, number of patients.			
20, number of surgically identified internal openings.			
28, number of surgically identified fistulous tracts, including primary and secondary tracts.			
Values are n/N (%). *CI* confidence interval, *MRI-AFG* MRI anterograde fistulography; The 95% CIs are exact Clopper-Pearson intervals.			

Position of internal opening

The clock-face position was correctly identified for 15/20 internal openings (75%) with MRI-AFG and 11/20 (55%) with conventional MRI (Table 2). These descriptive results suggest that MRI-AFG may provide more precise localization.

Distance from the anal verge to the internal openings

The distance was measured within 5 mm of the surgical reference for 11/20 internal openings (55%) with conventional MRI and 15/20 (75%) with MRI-AFG (Table 2). MRI-AFG showed higher descriptive agreement with intraoperative distance measurements in this cohort.

Number and classification of fistulas

Conventional MRI detected more fistulous tracts than MRI-AFG (25/28 [89.3%] vs 21/28 [75.0%], respectively; Table 2). However, maximum-intensity-projection (MIP) images generated from MRI-AFG provided clearer visualization of tract patency and communications among branches in complex fistulas (Fig. 3). The nominal exact 95% CIs for these tract-level proportions were 71.8–97.7% and 55.1–89.3%, respectively.

Although contrast medium did not enter six fistulous tracts, these tracts remained visible as linear low-signal-intensity structures on 3D LAVA-Flex images (Fig. 4). Conventional MRI and MRI-AFG showed the same agreement with the surgical Parks classification (11/12 [91.7%] for each; Table 2).

Discussion

This exploratory study evaluated the diagnostic performance and potential clinical value of MRI anterograde fistulography (MRI-AFG), a novel adjunctive technique for assessing anal fistulas based on the 3D LAVA-Flex sequence. The technique uses a defecation maneuver to facilitate the passage of rectally administered gadolinium contrast through a patent internal opening into a fistulous tract. Our preliminary findings suggest that MRI-AFG may aid visualization and localization of patent internal openings, delineation of primary and secondary fistulous tracts, and identification of communications among tracts, particularly in complex anal fistulas.

The study included 12 patients with surgically confirmed anal fistulas, comprising 20 internal openings and 28 fistulous tracts. Conventional MRI showed a slightly higher internal-opening detection rate than MRI-AFG (80% vs. 75%). This difference may partly reflect the ability of fat-suppressed T2-weighted imaging (FS-T2WI) to depict superficial active fistulous tracts [13, 15]. Conventional MRI did not detect all internal openings, possibly because the relatively large slice thickness of conventional sequences can obscure small openings through partial-volume effects [16]. The slightly lower number of internal openings detected with MRI-AFG (15 vs 16 with conventional MRI) may reflect internal-opening patency rather than inferior overall performance. Surgical exploration showed that 4 internal openings missed by MRI-AFG were occluded by granulation tissue or fibrosis. Intraoperative probing revealed distinct resistance and a breakthrough sensation when accessing these openings, which is consistent with the finding that gadolinium contrast could not penetrate the closed lumen. Such occlusion may be more common in chronic or recurrent fistulas, in which inflammatory healing can partially or completely close the internal opening [4, 8]. In such cases, conventional MRI may depict fibrous tissue adjacent to an occlusion as a patent internal opening, whereas the dependence of MRI-AFG on contrast passage may provide more direct information about internal-opening patency. This cohort also contained 1 small internal opening (≤ 2 mm) that may not have retained sufficient gadolinium for visualization. Although intraoperative probing confirmed its presence, this finding may further explain the discrepancy in internal-opening counts.

Conventional MRI showed a higher fistulous-tract detection rate than MRI-AFG (89.3% vs 75.0%). FS-T2WI has shown good performance in detecting active fistulous tracts [17]. Nevertheless, conventional MRI did not detect all fistulous tracts because FS-T2WI may be less sensitive to inactive tracts with minimal secretion and postoperative tracts characterized by scarring [18]. MRI-AFG detected fewer fistulous tracts than conventional MRI (21 vs 25); this difference may reflect the patency of the internal opening and tract rather than necessarily indicating poor performance. One potential explanation is that straining may create a pressure gradient from the anorectum toward a patent fistulous tract, facilitating the passage of contrast through its internal opening. This mechanism may facilitate visualization of

patent active tracts and may help distinguish them from nonpatent fibrotic tracts. Traditional retrograde percutaneous fistulography requires injection through an external opening, may be difficult when openings are small or multiple or when a tract is blind-ending, and can cause discomfort [9–11]. MRI-AFG avoids external-opening cannulation and may provide detailed visualization of patent internal openings and tract morphology with limited discomfort.

In one patient with a complex anal fistula, conventional MRI depicted only one internal opening and one fistulous tract, whereas MRI-AFG depicted two openings and two tracts. A tract closely adjacent to the anal verge may have been difficult to distinguish on conventional MRI. MRI-AFG may promote contrast filling of patent channels during straining, making some otherwise inconspicuous tracts visible. This dynamic approach may be clinically useful. This capability could assist detection of occult internal openings and branching tracts and thereby inform surgical planning.

MIP reconstructions from MRI-AFG allowed intuitive assessment of communications among fistulous tracts. These images may provide surgeons with a more complete map of relevant anatomy and reduce the risk of untreated segments in complex cases.

MRI-AFG more often correctly identified the clock-face position of internal openings and measured their distance from the anal verge than conventional MRI. These observations may be related to two features of the technique. Firstly, dynamic pressure simulation enables the contrast agent to better conform to the filling pathway of the fistula under physiological conditions. Secondly, the 3D sequences provide high-resolution isotropic images that can be reconstructed in different planes [8]. Together, these features may improve localization of the internal opening and measurement of its distance from the anal verge. Accurate localization of an internal opening and measurement of its distance from the anal verge are clinically important. These measurements can help surgeons determine incision direction and depth while avoiding excessive sphincter division, which can lead to fecal incontinence [15]. A 5-mm discrepancy in anorectal imaging may be clinically relevant because it can alter the surgical strategy for low- or mid-level anal fistulas [1], suggesting a potential role for MRI-AFG in quantitative anatomical assessment.

The high soft-tissue resolution of 3D LAVA-Flex allowed 6 fistulous tracts to be visualized as linear low-signal-intensity structures despite the absence of contrast entry. This finding may partly explain why MRI-AFG achieved 91.7% agreement with the surgical Parks classification, the same reported value as conventional MRI.

Taken together, these findings suggest that MRI-AFG should be considered an adjunct to, rather than a replacement for, conventional MRI. MRI-AFG may be particularly useful in complex anal fistulas with patent internal openings and tracts, for which accurate localization, distance measurement, and identification of communications among tracts may inform surgical planning.

This study has several limitations. First, the small sample size (n = 12) limited statistical power and generalizability. The small difference in internal-opening detection rates may have arisen by chance and

should be evaluated in larger cohorts. Second, the cohort included only 7 patients with complex anal fistulas; larger studies of severe disease are needed to clarify the utility of MRI-AFG in high-risk subgroups. Third, patients with recurrent fistulas or previous surgery were not excluded; because these factors may increase internal-opening occlusion, their inclusion could have reduced the sensitivity of MRI-AFG for detecting internal openings. In addition, Interobserver agreement was not quantitatively assessed, which may limit the reproducibility of the imaging evaluations.

Overall, MRI-AFG combined 3D LAVA-Flex imaging, defecation-induced contrast flow, and MIP reconstruction to provide adjunctive information about anal fistulas. Although its overall detection rates for internal openings and fistulous tracts were slightly lower than those of conventional MRI, MRI-AFG showed higher descriptive performance for localizing internal openings, measuring their distance from the anal verge, and depicting communications among patent tracts, particularly in complex fistulas. These preliminary findings support further evaluation of the feasibility and potential clinical utility of MRI-AFG. MRI-AFG may provide additional information for individualized surgical planning. Larger prospective studies are needed to confirm its diagnostic performance, safety, and effects on surgical outcomes and recurrence.

Declarations

Author Contribution

Study concepts: Lijie Dong and Yang Zhao. Study design: Dong L and Chen L. Data acquisition: Dong L, Geng Q, Liu F, and Chen L. Preparation of manuscript and figures: Geng Q, Liu F. Manuscript editing: Dong L. Manuscript review: Chen L and Zhao Y.

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Figures

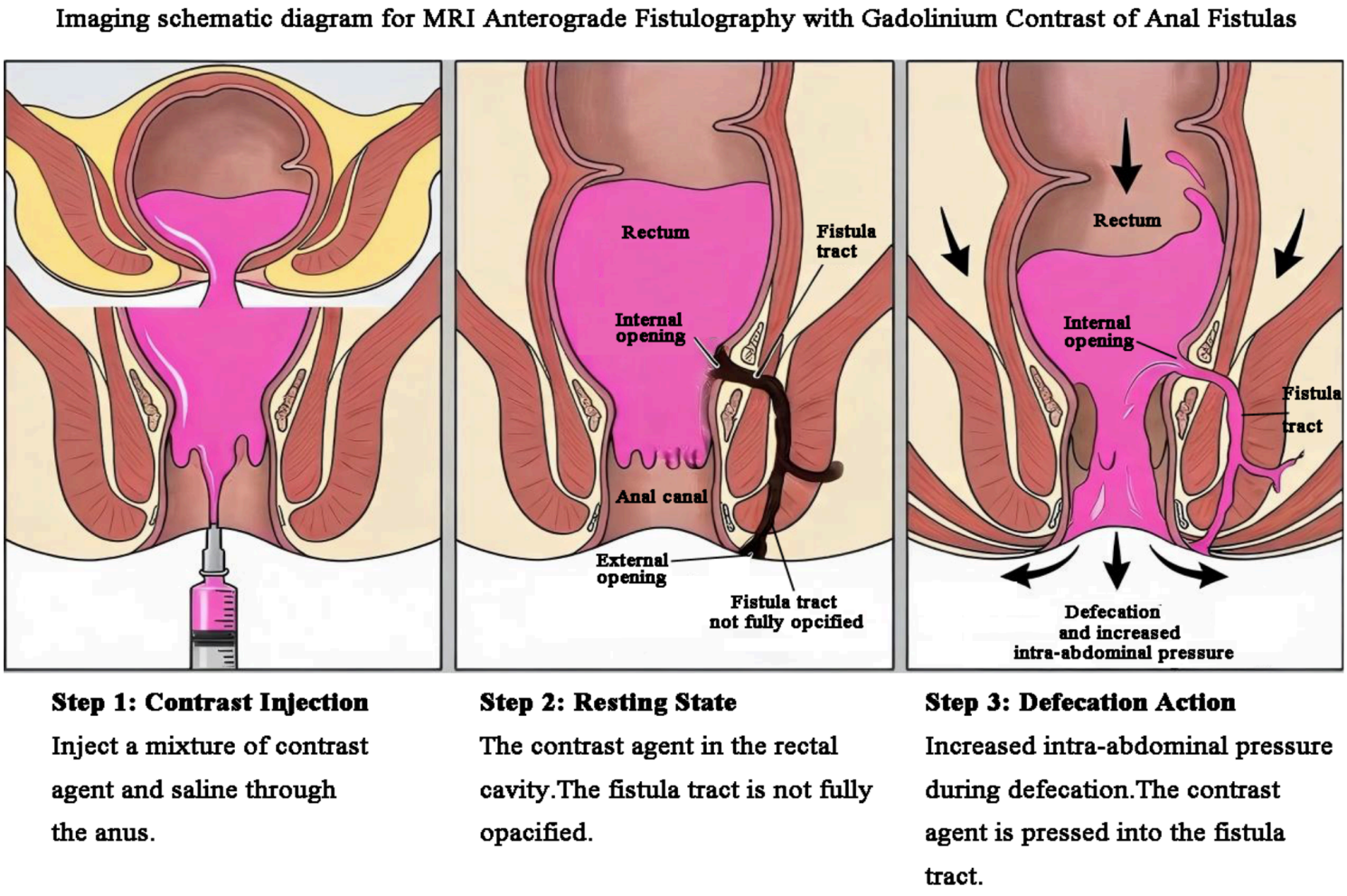


Figure 1

Schematic overview of rectally administered gadolinium and straining for MRI-AFG.

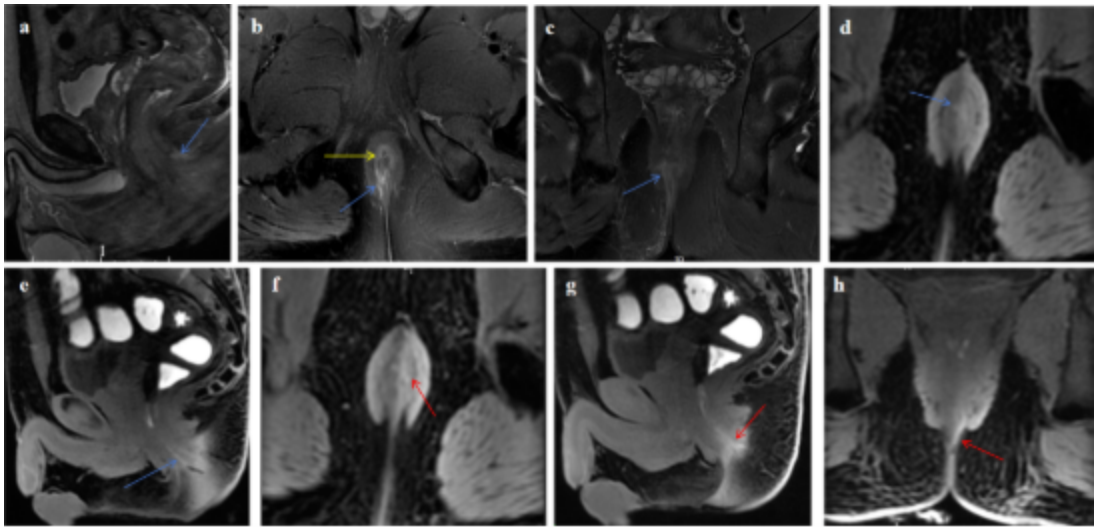


Figure 2

34-year-old man with anal fistula. (a–c) Sagittal, axial, and coronal FS-T2WI images show a hyperintense fistulous tract extending into the right buttock (blue arrow) and an internal opening at approximately the 9-o'clock position with the patient supine (yellow arrow). (d–h) MRI-AFG images show hyperintense contrast medium at the internal opening at approximately the 9-o'clock position (d, blue arrow), contrast entering the right fistulous tract (e, blue arrow), a left-sided internal opening at approximately the 5-o'clock position (f, red arrow), and contrast entering the left fistulous tract (g,h, red arrows).

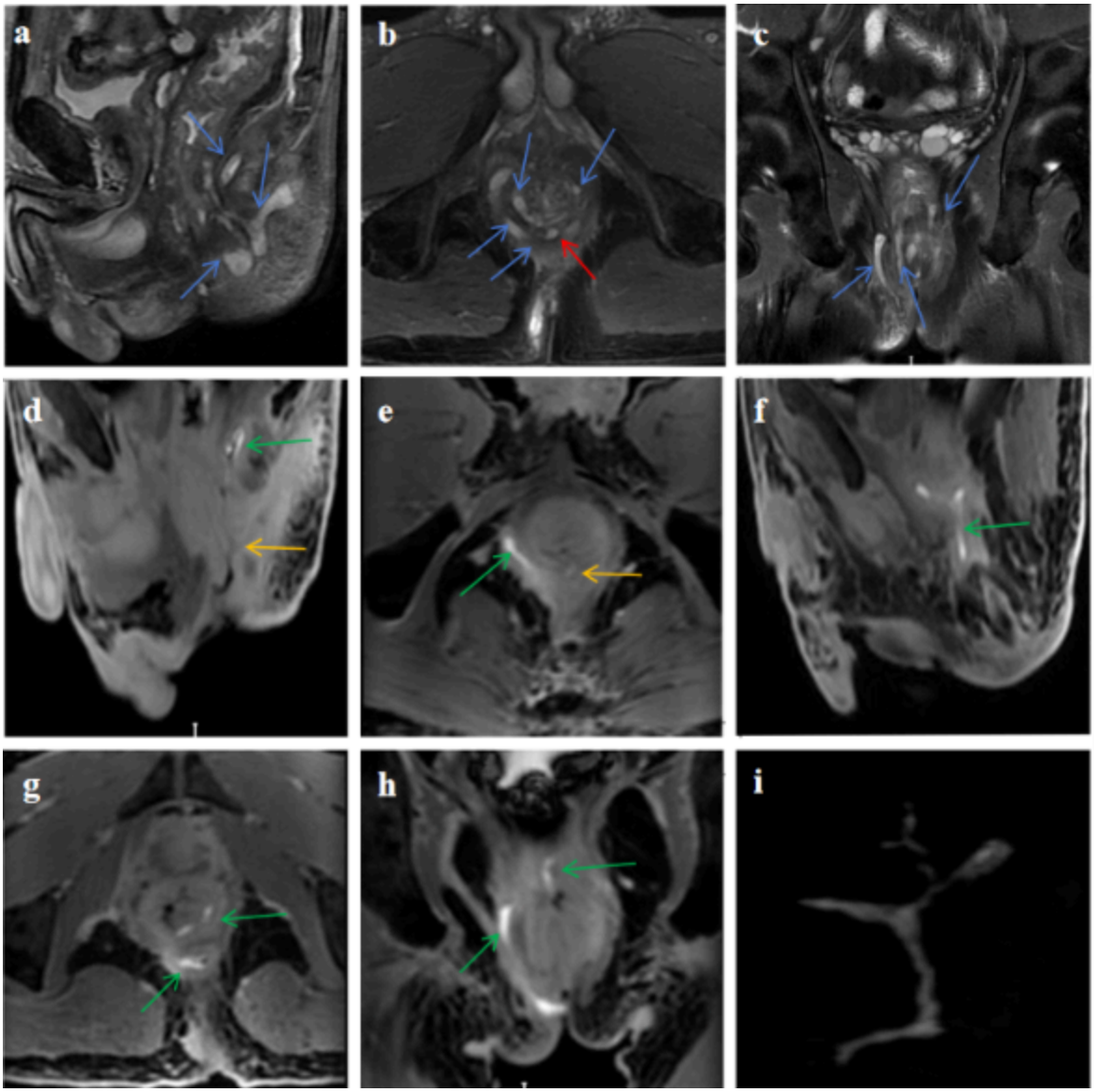


Figure 3

61-year-old man with complex anal fistula. (a–c) Sagittal, axial, and coronal FS-T2WI images show multiple hyperintense fistulous tracts (blue arrows). The internal opening is located at approximately the 6-o'clock position with the patient supine (red arrow). (d–h) MRI-AFG images show hyperintense contrast medium at the internal opening at approximately the 6-o'clock position (yellow arrow). Contrast medium within the fistulous tracts is hyperintense (green arrows). (i) A maximum-intensity-projection (MIP) reconstruction from MRI-AFG demonstrates communications among multiple fistulous tracts.

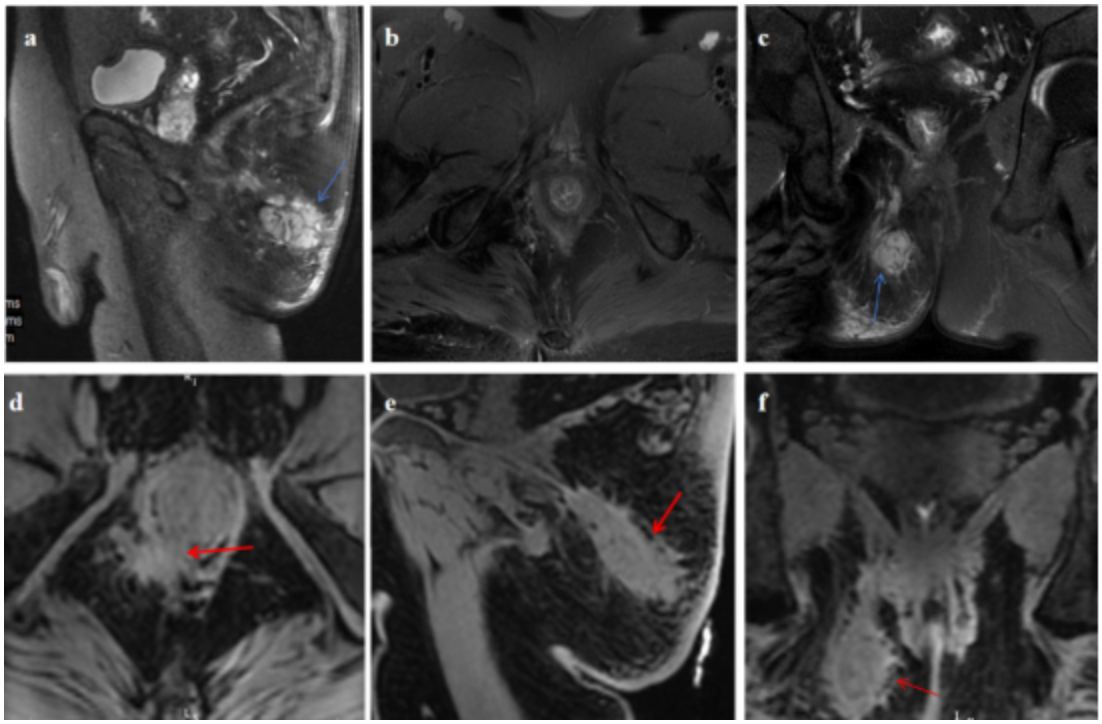


Figure 4

45-year-old man with anal fistula and abscess. (a–c) Sagittal, axial, and coronal FS-T2WI images show a hyperintense fistulous tract and abscess in the right buttock (blue arrow); no internal opening was identified. (d–f) MRI-AFG images show no contrast medium entering the suspected internal opening (d, red arrow), whereas the fistulous tract and abscess remain visible with isointense signal on e and f (red arrows).