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Direct hydrogen peroxide MRI fistulography versus indirect (intravenous) MRI fistulography in patients with perianal fistula

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Abstract

Background Perianal fistula is a rather common disease; its symptoms range from mild to severe, impairing anal continence; accurate preoperative evaluation avoids recurrence following surgical procedures.

Aim of work Our study examined the diagnostic accuracy of magnetic resonance imaging with direct percutaneous instillation of hydrogen peroxide mixed with gadolinium (direct fistulography) in comparison to intravenous gadolinium contrast-enhanced study (indirect fistulography).

Methods This prospective study was conducted on patients referred to Airforce hospital radiology department and were diagnosed with perianal fistula, Direct and indirect MR fistulography were performed using a 1.5T MRI scanner. The type of fistulae, internal openings, secondary branches, and abscesses were compared to surgical findings.

Results Our study included 35 male patients. Both direct and indirect methods detected primary tracts with 97.1% sensitivity and accuracy rates of 91.9% and 89.2%, respectively. The direct method was superior in detecting secondary branches and internal openings with accuracy rates of 97.37% and 93.3%, respectively, compared to 86.8% and 86.6% for the indirect method, while the indirect method was superior in detecting abscess collections with 100% accuracy rate compared to 89.2% accuracy rate for the direct method. None of the patients reported fever or bleeding after the procedure.

Conclusions Both direct and indirect fistulography showed comparable abilities in detecting primary fistulous tracts. However, the direct fistulography was superior in detecting internal openings and secondary tracts particularly in chronic cases, whereas indirect Fistulography was superior in detecting abscess collections. Incorporating both methods into our routine could thus improve the efficacy of surgical procedures.

Keywords MR fistulography, Perianal fistula, MRI

Background

Perianal fistula is described as a connection between the mucosal layer of the anal canal and the perianal skin [1] it is a relatively common disease impacting roughly (1–2 of 10,000) per year, with a male-to-female-ratio about 2:1 [2].

Perianal fistula is a frustrating disease that has a negative impact on the patient's quality of life. Symptoms range from mild perianal discomfort, pain, and recurrent discharges to anal incontinence, which is a complication following operative treatment. Anal incontinence is a physically and psychologically debilitating condition that has a negative impact on the patient's quality of life [3].

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The pathophysiology of perianal fistula is presumed to be cryptoglandular in nature, occurring as a result of chronic anal gland infection and sepsis. They are also more common in patient with an underlying medical condition, such as Crohn's disease, pelvic infection, diverticulitis, tuberculosis, and pelvic malignancy [1].

Most perianal fistulas are treatable surgically; however they have a significant recurrence rate. As a result, meticulous preoperative evaluation is needed to clarify the location and number of internal openings, secondary tracts, abscesses, the pathway of fistulas, and the relationship between fistula and adjacent structure,in order to design the treatment plan to improve prognosis and reduce the rate of recurrence [4].

There are various imaging diagnostic modalities, including fistulography, barium enema, computed tomography and endoscopic ultrasonography. However, those methods are limited and lack the precision to be clinically beneficial. As a result, Magnetic resonance imaging (MRI) has arose as the ultimate imaging modality and the modality of choice in the evaluation of the perianal fistula, being precise and non-invasive and able to display the anatomical structures due to its high soft tissue resolution and better tissue characterisation, which can efficiently demonstrate the extent of the transmural inflammatory process, secondary tracts and abscesses, aiding in the accurate selection of the most appropriate therapeutic approach, particularly in patients with a complex perianal fistula [5].

Nowadays, the widely accepted MRI sequences for the evaluation of perianal fistulas are including T2-weighted imaging (T2WI), fat-suppressed T2WI (T2WI-FS), and fat-suppressed T1WI (T1WI-FS). Moreover, utilising IV Contrast-enhanced T1-weighted imaging provides a better anatomic and pathologic depiction of fistula and enhance radiologists' confidence in detecting perianal fistulas [1].

A few trials were carried out to enhance the diagnostic efficiency of the MRI study by performing percutaneous injection of different contrast agents (such as aqueous jelly, gadolinium diluted in normal saline and a mixture of hydrogen peroxide and gadolinium) into the fistulous tract. It enabled more accurate delineation of the complex anatomy of fistulas, as well as more reliability in recognising internal openings, lateral ramifications, and tract multiplicity [6–8].

In our study, we will evaluate the diagnostic feasibility of percutaneous hydrogen peroxide injection (Direct MR fistulography) compared to gadolinium IV contrast-enhanced study (Indirect MR fistulography)in the evaluation of perianal fistulas.

Methods

- This prospective study was conducted on 35 patients who were referred from the surgical outpatient clinic for MR imaging of the perianal fistula between March 2021 and January 2023 at the Air-Force Hospital's Radiology department.
- All of the patients had one or more of the following signs and symptoms: perianal discharge, pain, perianal swelling, and induration.
- *Inclusion Criteria*

  Adult patients with any age group, with any of the following indications.

  Patients with clinically suspected perianal fistula with a patent orifice.
  Single or multiple discharging sinuses in the perianal region.
  Recurrent perianal abscess for detection of undetected tracts.

  Patients with recurrent peri-anal disease following surgically intervention were included.

- *Exclusion Criteria*

  Paediatric patients.
  Patients with abnormal renal functions.
  Patients with MRI-incompatible devices or implants.
  Patients with claustrophobia

- *Ethical Considerations*

  Official permission to carry out the study was obtained from the Research Ethics Committee of Ain shams university, Patients' consents of participation were obtained, and patients were assured not to be exposed to any harm or risk.
  We explained the procedure of imaging as well as the need for contrast agent administration in detail. All patients submitted informed written signed consent, and those who refused to participate in the study due to fear of pain were excluded.

All patients were gone through complete history taking, full clinical examination and revision of previous imaging if present and exclusion of contra-indicators.

No certain bowel preparation, just laxative or spasmolytic agent as a premedication, was recommended before the examination

Our studies were conducted on two separate days to avoid any conflicts between the two different studies and assure contrast washout.

Indirect MR fistulography was performed on patients using a 1.5T MRI scanner (GE Optima MR450W 1.5T clinical scanner; GE Healthcare). Patients were positioned supine, and images were acquired using a phased-array coil. The imaging volume was designed to include the distal rectum and subcutaneous tissue, as well as the anal canal, sphincter muscles, ischio-rectal fossa, levator muscle, and supralevator space, a power injector-assisted intravenous gadolinium contrast injection at mean dose of 0.1 ml/kg body weight were used, and sequences as showed in Table 1 were taken.

The patients then underwent Direct MR fistulography the next day: The contrast mixture was prepared ex-tempore in the proportion of a few drops of gadolinium per few cm^3 of 3% hydrogen peroxide prior to the examination, then patients were positioned prone in the MRI room, and a inspection, and palpation of the anal region were performed to detect the external opening. Once the external opening was identified, the anal region was cleansed with topical antiseptic and a butterfly cannula, ideally 24G or 26G without a catheter, was carefully introduced into the external orifice and the mixture was administered slowly using a 3ml syringe. Subsequently, the external orifice was covered with a plaster dressing and gauze.

Then a pelvic coil was centred on the patient's pelvis to cover the anal canal completely and sequences as shown in Table 1 were taken.

The digital MR images were evaluated by an experienced radiologist who had more than 10 years of clinical experience with pelvic MRI.

For a uniform description of perianal fistula, we have utilised the standard MRI template proposed by Szopinska [9], and used it to record and assess the following items in each method separately:

- Parks's classification, St. James University Hospital's Classification and Standard practice task force's classifications
- Location of the tract according to the anal canal using a clock dial description.
- Height, a low fistula traverses ≤ 1/3 of the anal canal, whereas a high fistula traverses > 1/3 of the anal canal.
- The cross-sectional diameter of the fistulous tract.
- Description of any abscess collection.
- Description of any secondary extensions.
- Number, location, and patency of the internal opening.
- the location of the external opening
- Chronicity of perianal fistula

Taking into consideration that any tract arising from the external opening is defined as a primary tract and any secondary tracts seen arising from these primary tracts were defined as lateral ramifications.

An abscess was defined as any fluid-filled collection larger than 10 mm in diameter according to Laniado [10], Post-contrast rim enhancing and internal air foci further corroborate the findings. A collection was deemed horseshoe if it crossed the midline to the contralateral side [11].

The perianal fistula was categorised based on Park's classification as shown in Table 2.

Another MRI classification system is St James's University Hospital with consists of five grades as showed in Table 3.

Table 1 Parameters of the used MRI sequences used for direct and indirect fistulography

MRI sequences	Non-contrast scan		Non-contrast fat-suppressed scan		Contrast-enhanced fat-suppressed scans(Indirect fistulography)	Percutaneous contrast-enhanced scan (Direct fistulography)
	T1W TSE	T2W TSE	FS T1W TSE	FS T2W TSE	FS T1W TSE	FS T1W TSE
Imaging plane	Oblique axial and coronal	Oblique axial	Oblique axialAxial	Oblique axial	Oblique axial, coronal and sagittal	Oblique axial, coronal and sagittal
TR (ms)	619	5486	591	4577	450	450
TE(ms)	10	110	10	50	10	10
FOV (mm)	250	260	260	250	260	260
Section thickness (mm)	3	3	3	3	3	3
Intersection gap (mm)	0.6	0 to 0.6	0.6	0 to 0.6	0 to 0.6	0 to 0.6
NEX	2	2	2	2	2	2
Matrix size	288 × 320	230 × 256	288 × 320	230 × 256	288 × 320	288 × 320

MRI magnetic resonance imaging, *TR* repetition time, *TE* echo time, *FOV* field of view, *T1W* T1 weighted, *T2W* T2 weighted, *TSE* turbo spin echo, *FS* fat suppressed, *NEX* Number of excitations

In clinical practise, The American Society of Colon and Rectal Surgeons' Standard Practice Task Force (SPTF) classification, which classify the perianal fistula as simple or complex, is the most widely used by surgeons.

- Simple fistula is considered as any low tract either inter-sphincteric or trans-sphincteric that has a solitary external opening with no perianal abscess or secondary branches.
- Complex fistula is considered as any high inter-sphincteric or trans-sphincteric or extra-sphincteric or supra-sphincteric tract, or any fistula having multiple external openings and associated with perianal abscess or secondary branches.

Surgery was performed by anorectal surgeons, and surgical findings were regarded as the gold standard reference. The surgical treatment plan was determined by surgeons based on physical examination and MRI examination.

Results

Statistical analysis

Data analysis was done using the statistical package for social sciences (SPSS) for Windows version 27.0 software package. For qualitative data, we applied Chi-square and Fisher's exact tests. The sensitivity, specificity, positive predictive value, negative predictive, and accuracy of each MRI method for individual fistula parameters were statistically analysed (Tables 4, 5, 6).

Results

Our study included 35 male patients with a mean age of 36.69 years, with the age group ranging from 20 to 65 years.

Thirty-four fistula tracts were surgically proven as fistulous tracts and 3 were identified as perianal sinus. The external opening was identified in all patients; the majority of patients thirty-three (89.2%) had single external opening, and four patients (10.8%) had two external openings; the most common location for the external opening was the right perianal cleft (56.8%).

Table 2 Parks classification for perianal fistula

Fistula type	Course of the perianal fistula
Inter-sphincteric fistula	The fistulous tract lies in the inter-sphincteric space but does not traverse the external anal sphincter
Trans-sphincteric fistula	The fistulous tract traverses the external anal sphincter and then traverses through the ischioanal/ischiorectal fossa
Supra-sphincteric fistula	The tract traverses above in the inter-sphincteric space above the puborectalis muscle and then descends through the iliococcygeus muscle into the ischiorectal fossa
Extra-sphincteric fistula	The tract traverses through the ischiorectal fossa, the levator ani sphincter complex, and opens into the rectum in the supra-levator region above the anal sphincter

Table 3 St James's University Hospital classification

Fistula type	Course of the perianal fistula
Grade I	A simple inter-sphincteric fistula without any secondary tract/ramification or abscess
Grade II	An inter-sphincteric fistula associated with secondary tract/ramification or abscess
Grade III	A trans-sphincteric fistulous tact without any secondary tract or abscess
Grade IV	A trans-sphincteric Fistulous Tract Along Associated with Secondary tract/ ramification or abscess
Grade V	Any fistulous tract with supralevator or translevator extension

Table 4 Surgical correlation with Direct and indirect MRI finding

Findings	Direct fistulography				Indirect fistulography			
	True positive	True negative	False positive	False-negative	True positive	True negative	False positive	False-negative
Primary tract	33	1	2	1	33	0	3	1
Secondary tract	11	26	0	1	9	24	3	2
abscess	6	27	0	4	10	27	0	0
Internal orifices	41	1	2	1	39	1	2	4

Table 5 Comparison of diagnostic efficacy in both direct and indirect fistulography in the detection of primary tract, secondary tract internal orifice and secondary abscess collection

MRI imaging finding	Direct fistulography (%)	Indirect fistulography (%)
Primary tract		
Sensitivity	97.1	97.1
PPV	94.3	91.7
Accuracy	91.9	89.2
Secondary tract		
Sensitivity	91.6	75
Specificity	100.0	92.3
PPV	100.0	81.8
NPV	96.3	88.8
Accuracy	97.37	86.8
Abscess collection		
Sensitivity	60.0	100.0
Specificity	100.0	100.0
PPV	100.0	100.0
NPV	87.1	100.0
Accuracy	89.2	100.0
Internal orifices		
Sensitivity	97.6	90.7
PPV	95.3	95.1
Accuracy	93.3	86.6

TP true positive, *TN* true negative, *FP* false positive, *FN* false negative, *PPV* positive predictive value, *NPV* negative predictive value

Table 6 Comparison of accuracy rates in the depiction of perianal fistulas and their associated findings in correlation with surgical results

	Number %	Direct fistulography (%)	Indirect fistulography (%)
Primary tract	34 (100%)	91.9	89.2
Associated abscesses	10 (100%)	89.2	100
Secondary tract	16 (100%)	97.6	75.6
Internal opening	42 (96.6%)	93.3	86.6

According to Park's classification system, the most common type of fistula encountered was the intersphincteric type, which was seen in 18 patients (48.6%), transsphincteric fistulas were seen in 14 patients (37.8%), whereas supra-sphincteric fistulas were identified in two patients (5.4%). No extrasphincteric fistulas were identified; nevertheless, three (8.1%) fistulas were identified as perianal sinus in postoperative findings**,** according to the St. James's University Hospital classification ten fistulas(27%) were grade I, eight fistulas (21.6%) were grade II, eight fistulas(21.6%) were grade III, six fistulas (16.2%) were grade IV, and two fistulas (5.4%) were grade V, according to SPTF classification, 14 fistulae were categorised as simple (37.8%) and 20 fistulae were complex (54.1%) (Table 7).

In regards of perianal fistula location, the most common site was anterior 16 (43.2%), while the second most common site was posterior 13 (35.1%),24 (64.9%) fistulas were recognised as low fistula and 10 (27%) fistulas were identified as high fistula. Low fistulas occurred more frequently than high fistulas.

There was a statistically significant difference in the mean diameter of the fistula between the direct and indirect fistulography, with a mean of 7.84 mm for direct and 5.22 mm for indirect, respectively, with p value < 0.01 (Fig. 1).

Both direct and indirect MR fistulography showed high sensitivity in detection of the primary fistula, both had 97.1% sensitivity and were able to detect 33 out of 34 tracts, Nonetheless, the direct fistulography was superior in terms of accuracy rate, with 91.9% accuracy rate vs 89.2% accuracy rate for the indirect fistulography. Both direct and indirect fistulography showed significant correlation with surgical findings with p value < 0.01 (Table 5).

In terms of secondary branches detection, the intersphincteric location was the most prevalent site of the secondary tract (87.5%) 0.12 secondary branches were surgically proven. The direct fistulography showed 91.6% sensitivity and 100% specificity with an accuracy of 97.37% and correctly detected 11 branches out of 12 branches, whereas the indirect fistulography was able to detect 9 out of 12 secondary branches with 75% sensitivity and 86.8% accuracy, the indirect fistulography showed 2 false-positive tracts which were absent in surgery reports and by reviewing images they presumed to be prominent vessels mimic secondary branches (Tables 1, 5).

There was a statistically significant association between surgery and both direct and indirect fistulography in detecting secondary tracts in chronic patients, with p values < 0.01, 0.02, respectively (Fig. 2).

In terms of abscess collections, the indirect fistulography was superior with a sensitivity of 100% and 100% accuracy, correctly diagnosing 10 out of 10 collections, whereas the direct method could only detect 6 out of 10 with a sensitivity of 60% and 89.2% accuracy, three horseshoe collections were identified (30%), and the most common location of abscess collections was at the ischioanal region. There was a statistically significant association between surgery and both direct and indirect fistulography in detecting abscess collection, with p values < 0.01 (Tables 2, 5).

Table 7 Comparison of fistulas tract according to parks classification, standard practice task force (SPTF) and St's James hospital grading MRI classification

	Surgery		Direct fistulography		Indirect fistulography	
	No	%	No	%	No	%
Parks classification						
Inter-sphincteric	18	48.6	21	56.8	21	56.8
Trans-sphincteric	14	37.8	13	35.1	13	35.1
Supra-sphincter	2	5.4	1	2.7	2	5.4
Sinus	3	8.1	2	5.4	1	2.7
SPTF classification						
Simple	14	37.8	17	45.9	17	45.9
Complex	20	54.1	18	48.6	19	51.4
Sinus	3	8.1	2	5.4	1	2.7
St's James classification						
I	10	27	12	32.4	12	32.4
II	8	21.6	8	21.6	9	24.3
III	8	21.6	8	21.6	6	16.2
IV	6	16.2	5	13.5	7	18.9
V	2	5.4	2	5.4	2	5.4
Sinus	3	8.1	2	5.4	1	2.7

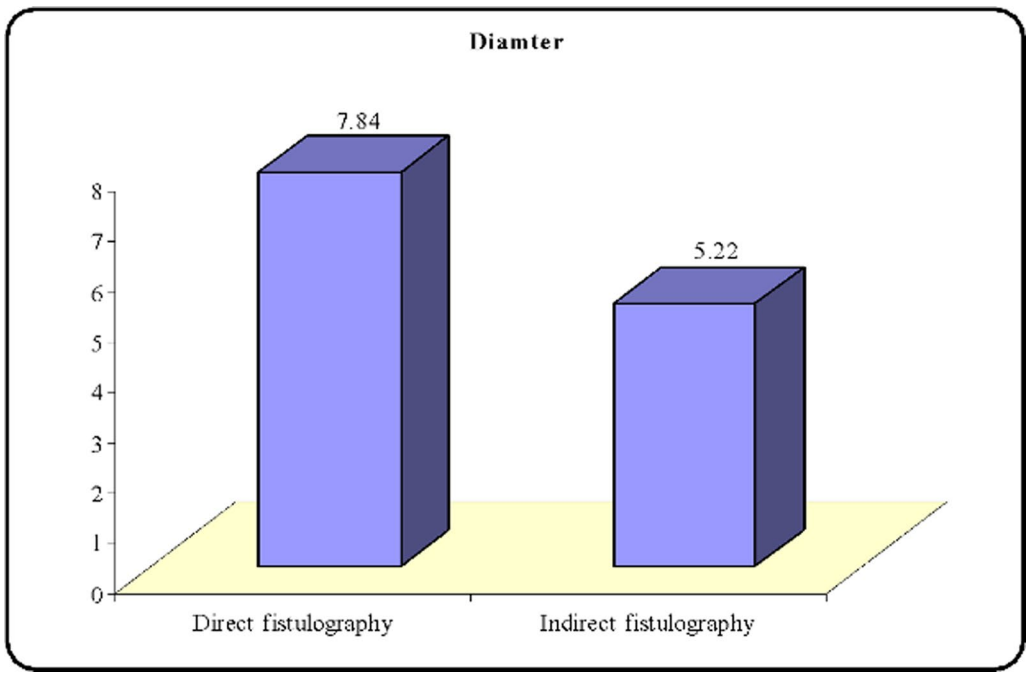

Fig. 1 Bar chart displaying the difference between the mean diameter of the primary fistula's tract in mm

In terms of internal orifice visibility, the most common position of the interior opening was identified at 6 o'clock, followed by 12 o'clock 0.42 internal orifices were identified intraoperatively; the direct fistulography was able to visualise 41 of 42 with a sensitivity of (97.6%) and accuracy of (93.3%), while the indirect fistulography was able to detect 39 of 42 with a sensitivity of 90.7% and an accuracy rate of 86.6% (Tables 3, 5).

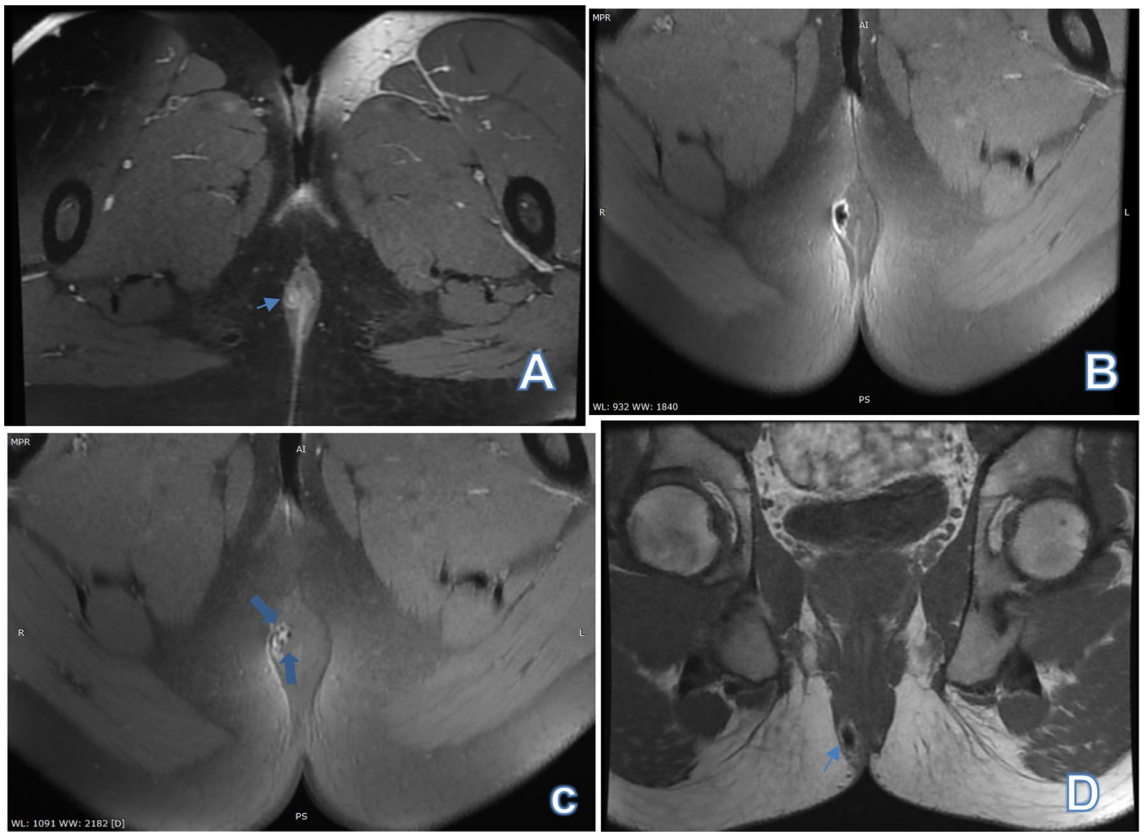

Fig. 2 **A** Axial IV CE T1 FS (indirect fistulography), **B**, **C** axial T1 FS (direct fistulography). **D** coronal T1 (direct fistulography) shows an inter-sphincteric fistula (arrow) which appears as a simple one, in the indirect images (**A**). However, in direct fistulography images (**B**–**D**) there is a significant distention and increased mean diameter of the fistula tract. Two additional side orifices were identified (block arrow)

Table 8 Association and correlation of chronicity with St 'James classification of direct and indirect fistulography showed The correlation between St 'James classification and their association with the chronicity of perianal fistula is significant, as we can see that the *p* value for all direct and indirect fistulography classifications is less than 0.05, i.e. (*p* 0.05)

	Direct fistulography	Indirect fistulography
Chronicity		
Correlation Coefficient (r)	**.573***	**.651***
Sig. (2-tailed) (p value)	**.000**	**.000**
No	37	37

Correlation is significant at the 0.01 level (2-tailed)

Correlation is significant at the 0.05 level (2-tailed)*

The patient history and Inflammatory changes surrounding the fistulous tract were the marker of chronicity. Of the identified perianal fistulous, 26 (70.3%) were chronic, while 11 (29.7%) were acute. It was statistically determined that there was a substantial Association of surgery with different classification of direct and indirect fistulography when patients present with chronic state, with a p value < 0.05 (Table 8).

Discussion

Effective surgical treatment of perianal fistulas reduces post-operative recurrence, but accurate identification of the primary tract and its relationship to surrounding structures is necessary. Physical examination alone may not be sufficient, and missing minor components during vc xsurgery can lead to post operative recurrence. [4]

Among several radiological imaging approaches for evaluating perianal fistulas, MRI is considered the modality of choice, Because of its tolerability, non-invasiveness and high-resolution imaging, with a high detection rate of the perianal fistula ranging from around 82.7% to 97% as reported in different studies [12], furthermore, other studies described up to 100% sensitivity for detecting the primary tract [13].

The most widely accepted MRI sequences for evaluation of the perianal fistula are T2WI sequences and intravenous contrast-enhanced T1W sequences. Many studies

have shown that intravenous contrast enhancement can provide more anatomic and pathologic depiction of perianal fistulas [1].

However, the disadvantages of contrast-enhanced studies include increased examination duration and cost, as well as an increased risk of nephrogenic systemic fibrosis in patients with kidney diseases. Furthermore, multiple studies have linked repetitive use of gadolinium with its deposition in deep nuclei of the brain [1].

Some authors investigated percutaneous instillation of different contrast agents (such as aqueous jelly, gadolinium contrast diluted in normal saline, and mixture of hydrogen peroxide and gadolinium) into the fistula tract, in hopes of enhancing the diagnostic efficiency while reducing the adverse effect of using intravenous contrast agents. Their studies showed better delineation of the complex anatomy of fistulae and reliability in identifying internal openings, lateral ramifications, and multiplicity of tracts [6–8].

Aggarwal [6] investigated the added benefit of percutaneous instillation of aqueous jelly into the perianal fistula and found a sensitivity and specificity of 100% in identifying the type of tract and a sensitivity of 94.2% and specificity of 100% in identifying internal openings with the accuracy of 95.3%, and 100% sensitivity in identifying ischioanal collections and 90.5% sensitivity and 100%, specificity and 97% accuracy in detection of the lateral ramifications [6].

Essawy [8] investigated the instillation of gadolinium contrast diluted in normal saline into the fistulous tract and found that it had a 100% sensitivity and specificity in identifying the type of fistula tracts, and a 96% sensitivity in identifying internal openings, and a 100% sensitivity in detecting ischioanal collections.

Waniczek [7] have discussed the direct percutaneous inject a mixture of hydrogen peroxide 3% and gadolinium into the perianal fistula it comes out with a potential result, however, his study was limited in patient population as it was done on 12 patients, motivating us to expand the population and investigate it's diagnostic feasibility.

Hydrogen peroxide acts as a potential rule in wide variety of pathological conditions such as inflammation in deep tissues, because of its relative stability and diffusibility [14]. It reacts with tissues causing oxidative stress and increasing the concentration reactive oxygen species, reducing their T1WI relaxivities, Furthermore, it have a high oxidative property, so it could promote mechanical and chemical purification of the fistula canal's tissue, altering its texture, increasing overall adherence of contrast agents to its walls [15].

In a previous study on an animal muscle tissue with an induced canal using diathermy, the application of a hydrogen peroxide mixture of gadolinium interacts with inflamed tissue and blood, catalysing and decomposing into water and oxygen, which distends the tract and allows the contrast to adhere to tract's wall, allowing better tissue delineation [7].

In this study, both direct and indirect fistulography showed high sensitivity in detecting primary fistula tracts, with both having 97.1% sensitivity and being able to detect 33 out of 34 surgically proven tracts, which was similar to a study made by Singh [16] that showed sensitivity of 95.5% in detecting primary tracts, Nevertheless, the direct fistulography was slightly superior in terms of accuracy (91.9% vs. 89.2%) (Table 4).

The intersphincteric type was the most prevalent, accounting for 18 (48.6%) of the patients, followed by trans-sphincteric type 14 (37.8%), and suprasphincteric type in two (5.4%), the results were similar with the findings in other studies [17–19], Nonetheless, the trans-sphincteric fistula was the most prevalent type in fewer other research [20].

In our study, both direct and indirect methods showed high sensitivity and accuracy in the identification of internal openings however the direct fistulography performed better in terms of accuracy (93.3%) and sensitivity (97.6%), the indirect method demonstrated an 86.6% accuracy rate and 90.7% sensitivity (Fig. 3), which was comparable to prior studies, for example, Singh [16] showed 85.42% sensitivity and 85% accuracy rate for T1WI CE sequence, Das [11] demonstrated 84.9% accuracy rate for sagittal CE FS T1W and 94.3% for axial and coronal CE FS T1WI. The internal orifice of the perianal fistula was mostly located at 6 o clock (31%), which was similar with DAS study [11] (Fig. 4).

Nevertheless, failure to identify some internal orifices may be attributable to anatomical or functional factors such as narrowed openings or being temporarily closed at the time of the test [21].

In terms of secondary branches detection, 12 side branches were discovered intraoperatively, and direct fistulography accurately diagnosed 11 out of 12 branches with 91.6% sensitivity and 97.36% accuracy. The indirect fistulography, on the other hand, was able to detect 9 out of 12 secondary branches with 75% sensitivity and 86.8% accuracy (Fig. 2). The indirect fistulography revealed two false positive tracts but were absent in surgical reports, they were assumed to be prominent hemorrhoidal vessels. Different studies [7, 8] have also described prominent vessels that may be misdiagnosed as secondary tracts and provide a diagnostic dilemma (Fig. 5).

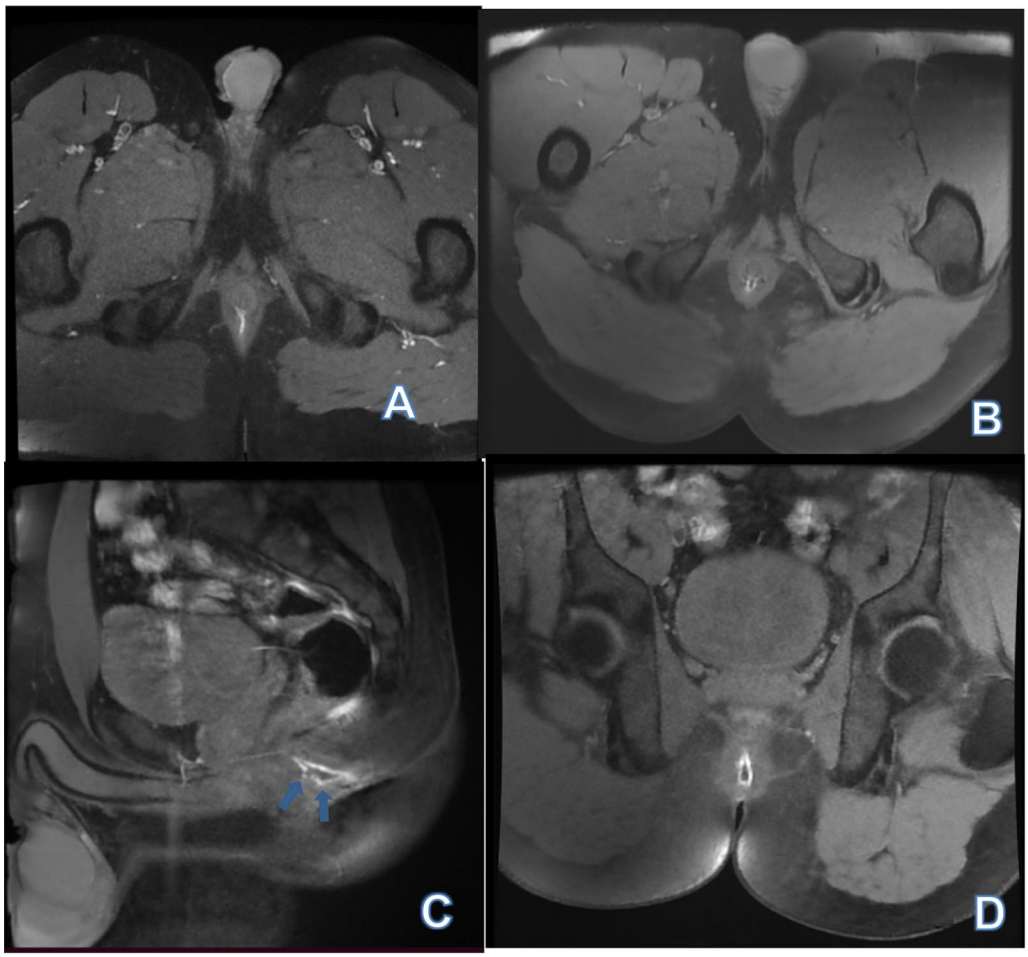

Fig. 3 **A** Axial IV CE T1 FS (indirect fistulography), **B** axial, **C** sagittal, **D** coronal T1 FS (direct fistulography), shows an inter-sphincteric fistula with additional secondary orifices depicted with direct fistulography (arrows in **C**)

The finding of indirect fistulography was similar to Singh [16] that showed sensitivity of 81.25% and a 90% accuracy rate of the post-contrast T1W FS., some branches could not be seen by either method which may be because of debris or fibrotic tissue clogging these tracts.

Regarding abscess collections, the indirect fistulography was superior in the detection of the abscess collections with a sensitivity of 100% and 100% accuracy and has correctly diagnosed 10 out of 10 collections, these results correspond with results obtained by previous studies [20, 21], which report a high detection rate of up to 100% for IV contrast T1W study. While the direct fistulography was only able to detect 6 out of 10 abscess collections with a sensitivity of 60% and an accuracy of 89.2%, the direct fistulography fails to adequately delineate the abscess collection and adjacent inflammatory tissue beyond the fistula wall, in contrast the indirect fistulography was able to target and delineate the inflammatory process efficiently (Fig. 4).

The direct fistulography was unable to detect supralevator collection. This is because, in our approach, we gently injected a few centimetres of the mixture into the tract; violent injection was not advised since it may cause extravasation of the mixture into the pelvic veins, which could lead to portal pyemia [17].

Our study found a significant difference in the mean diameter of the tracts between direct and indirect fistulography, with direct fistulography having a larger mean diameter because the emitted oxygen during technique caused distention of the fistulous tract, resulting in more accurate depiction of those tracts, particularly in chronic ones that may appear collapsed.

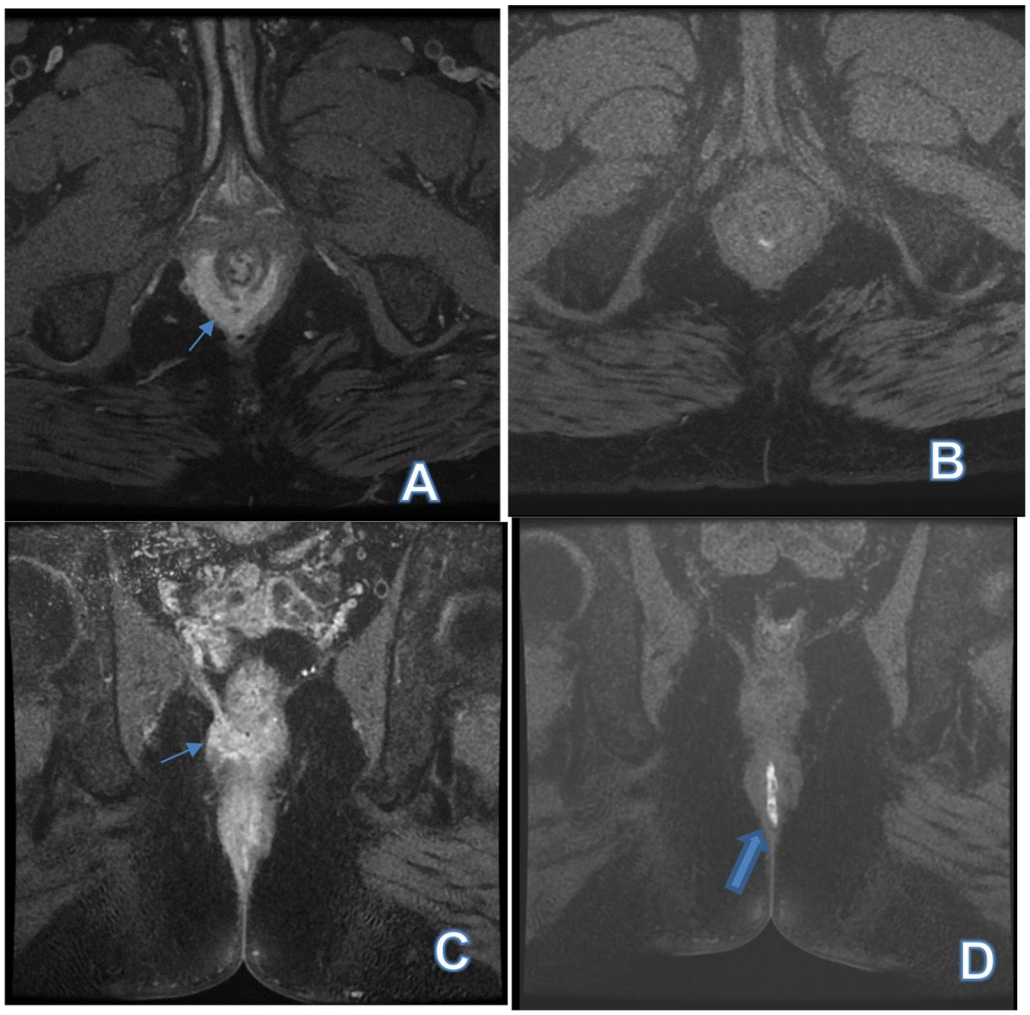

Fig. 4 **A** Axial, **C** coronal IV CE T1 FS (indirect fistulography), **B** axial, **D** Coronal T1 FS (direct fistulography), show supra-sphincteric complex fistula with a horseshoe collection (arrows) which is Cleary depicted using indirect fistulography (**A**, **C**), while the direct fistulography (**B**, **D**) shows only the fistula tract (block arrow) and could not identify the horseshoe collection

With a p value of 0.01 for both direct and indirect fistulography, there was a substantial correlation with surgical result, and also it was statistically determined that there was a substantial association of surgery with different classification of direct and indirect fistulography when patients present with chronic state, with p value < 0.05.

A few patients complained of short-term discomfort during percutaneous contrast administration; however, slower contrast administration allowed those complaints to be minimised. None of the patients reported fever or bleeding.

There are several limitations to this study initially, surgical results were considered as the gold standard for our study. Yet, as previously documented in the literature, certain tiny fistulas and associated pathologies may be overlooked during surgery. Furthermore, because the number of patients participating in this study was the modest, there were fewer patients with rare types of perianal fistulae, which can be resolved in follow-up work by expanding the sample size.

Conclusions

In our current study, both direct and indirect fistulography demonstrated comparable abilities in detecting primary fistulous tracts with similar sensitivity, the direct fistulography was slightly more accurate, and was superior in detection of internal openings and secondary tracts with greater accuracy, the indirect fistulography was superior in the detection of abscess collections, active inflammatory processes, and high pathological component, which emphasises that both methods could be integrated, and we could benefit from incorporating

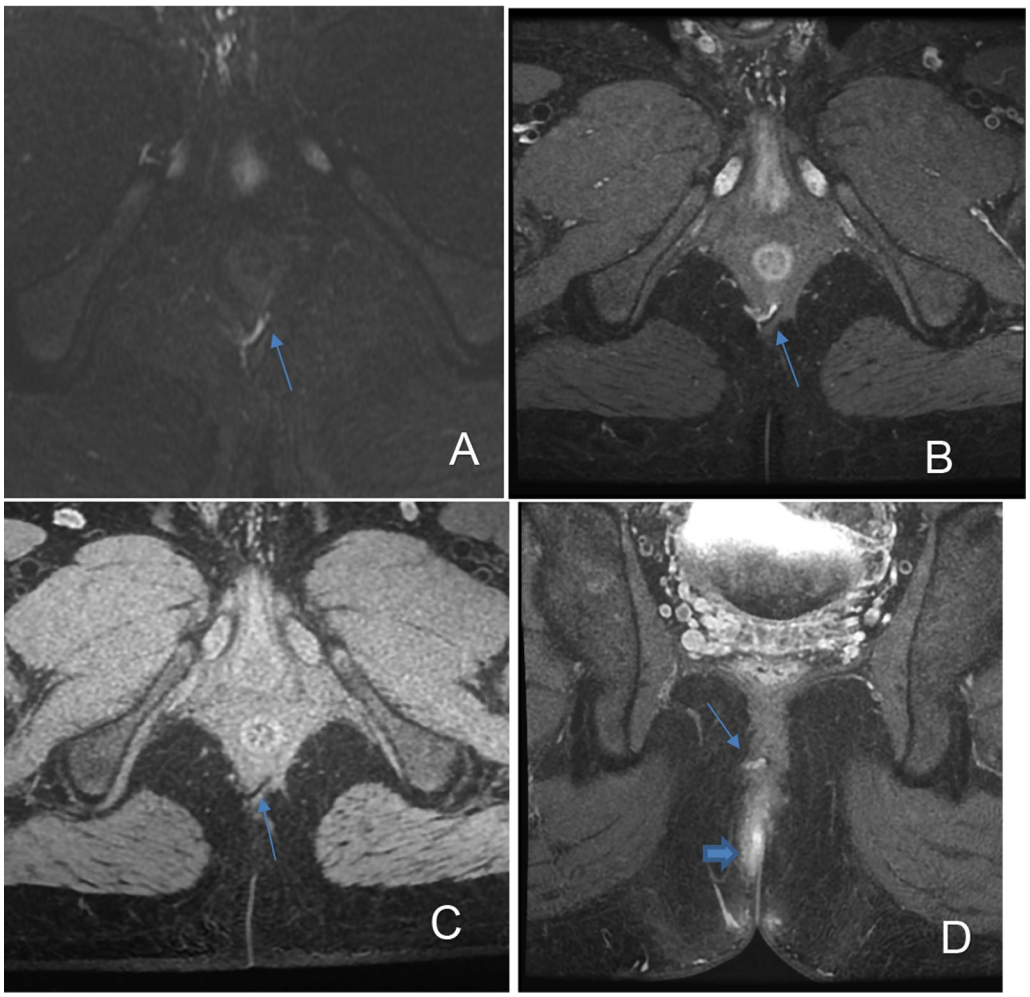

Fig. 5 **A** Axial T2 Fat sat sequence, **B** axial, **D** IV CE T1 FS (indirect fistulography), **C** T1 FS direct fistulography, show a prominent vessel (arrow) that is hyperintense in T2WI and shows contrast enhancement at indirect fistulography images **B**, **D**, which could be misinterpreted as a secondary branch, however, it shows no contrast delineation in the direct fistulography (**C**)

direct fistulography into our routine to help in precise planning the surgical procedure and to avoid postoperative recurrence, particularly in the chronic cases.

As a result of its strong diagnostic values, we propose adopting the combination technique for preoperative evaluation.

Abbreviations

CE	Contrast enhanced
FS	Fat suppression
G	Gauge
GE	General electric
IV	Intravenous
MR	Magnetic resonance
MRI	Magnetic resonance imaging
SPSS	Statistical package for social sciences
SPTF	Standard Practice Task Force
T1WI	T1 weighted images
T2WI	T2 weighted images
T2WI-FS	T2 weighted images-Fat suppression

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Author contributions
All authors contributed to the study's conception and design. Material preparation, data collection, and analysis. All authors have read and approved the manuscript.

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Availability of data and materials
The data supporting this study's findings are available from the corresponding author upon reasonable request.

Declarations

Ethics approval and consent to participate

Official permission to carry out the study was obtained from the Research Ethics Committee (REC) of Ain Shams University. Patients' consents of participation were obtained, and patients were assured not to be exposed to any harm or risk. We explained the procedure of imaging as well as the need for contrast agent administration in detail. Informed written signed consents were obtained from all the patients, and those who refused to conduct the study out of fear of pain were excluded from this study.

Consent for publication

All patients included in this research were fully conscious and older than 18-year-old and gave written informed consent to publish the data contained within this study.

Competing interests

We did not receive payment for participating in the study and had no personal motivation for the study outcome. The other authors of this manuscript have no financial interests.

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