**Name of journal:** *World Journal of Radiology*

**ESPS Manuscript NO:** 7431

**Columns:** Case Control Study

**Comparison of different magnetic resonance imaging sequences for assessment of fistula-in-ano**

Torkzad MR *et al.* Optimal MRI of fistula-in-ano

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**Author contributions:** Torkzad MR and Karlbom U collected the data; All authors analysed and interpreted the data; Torkzad MR originally drafted the manuscript; Ahlström H and Karlbom U revised the manuscript.

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**Received:** November 17, 2013  **Revised:** January 27, 2014

**Accepted:** April 17, 2014

**Published online:**

**Abstract**

**AIM:** To assess agreement between different forms of T2 weighted imaging (T2WI), and post contrast T1 weighted imaging (T1WI) in depiction of fistula tracts, inflammation and internal opening with that of reference test.

**METHODS:** Thirty nine consecutive prospective cases were enrolled. The following sequences were used for T2WI: 2D turbo-spin-echo (2D T2 TSE); 3D T2 TSE; STIR (short tau inversion recovery); 2D T2 TSE with fat saturation performed in all patients. T1WI were either 3D T1-weighted prepared gradient echo sequence with fat saturation or 2D T1 fat saturation (SPIR). Agreement for each sequence for determination of fistula extension, internal opening and presence of active inflammation was assessed separately and blindly against reference test, comprised of follow-up, surgery, endoscopic ultrasound and assessment by an independent experienced radiologist with access to all images.

**RESULTS:** Fifty-sixfistula tracts were found: 2 inter-sphincteric, 13 trans-sphincteric and 24 with additional tracts. The best T2 weighted sequence for depiction of fistula tracts was 2D T2 TSE (Cohen’s kappa = 1.0), followed by 3D T2 TSE (0.88), T2 with fat saturation (0.54) and STIR (0.19). The internal openings were best seen on 2D T2 TSE (Cohen’s kappa = 0.88), followed by 3D T2 TSE (0.70), T2 with fat saturation (0.54) and STIR (0.31). Detection of inflammation showed Cohen’s kappa of 0.88 with 2D T2 TSE, 0.62 with 3D T2 TSE, 0.63 with STIR and 0.54 with T2 with fat saturation. STIR, 3D T2 TSE and T2 with fat saturation did not make any contributions in any case compared to 2D T2 TSE. Post contrast 3D T1 weighted prepared gradient echo sequence with fat saturation showed better agreement in depiction of fistulae (Cohen’s kappa = 0.94), finding inner openings (Cohen’s kappa = 0.97) and evaluation of inflammation (Cohen’s kappa = 0.94) compared to post contrast 2D T1 fat saturation or SPIR where the corresponding figures were 0.71, 0.66 and 0.87, respectively. Comparing the best T1 and T2 sequences, showed that for best results, both sequences were necessary.

**CONCLUSION:** 3D T1 weighted sequences were best for depiction of internal openings and active inflammatory component, while 2D T2 TSE provided best assessment of fistula extension.

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**Key words:** Fistula; Magnetic resonance imaging; Diagnosis

**Core tip:** Both T1 (post contrast) and T2 weighted sequences are needed for best assessment of fistula-in-ano; 2D T2 TSE is most useful for depiction in relation to sphincter muscles. 3D T2 TSE cannot replace 2D T2 TSE; Post contrast 3D T1 weighted prepared gradient echo sequence with fat saturation is necessary for depiction of internal openings and inflammation activity; STIR and fat saturated T2 sequences should be omitted from protocols.

Torkzad MR, Ahlström H, Karlbom U. Comparison of different magnetic resonance imaging sequences for assessment of fistula-in-ano.

**Available from:**

**DOI:**

**INTRODUCTION**

Treatment of fistula-in-ano requires adequate knowledge of its extensions[1-5]. Magnetic resonance imaging (MRI) is the single best imaging modality for this purpose, though sometimes the addition of other tests such as endoanal ultrasound (EUS) is required. During the recent years the focus of MRI research on fistula-in-ano has been two-fold. Previously most researches had focused on comparing MRI with EUS or examination under anesthesia (EUA)[6-8]. During more recent years, as efficacy of MRI has been more established, the focus of research has shifted to assessment of inflammatory activity. When it comes to choosing the right sequences however there is only one published original study by Halligan *et al*[9] and that was 1998. Since then, there has been no study concerning the choice of sequences. There have been multiple review articles where experienced authors have mentioned their protocols, albeit with some differences[10-13].

The fistula-in-ano is particularly different from other fistulae[14]. While detection of a fistula is the primary concern with other abdominal fistulae, for fistula-in-ano this is usually established by the surgeon before imaging. Indeed the most important clinical indication for imaging in fistula-in-ano is assessment of fistula extension. The reason for this is that fistula-in-ano can affect the anal sphincter complex and inadvertent damage to this complex can impair continence. This means that while fat-saturated sequences can increase the detection rate of thin fluid filled fistulae, we still need enough anatomic details to determine fistula extension.

The sequences used for fistula-in-ano imaging consist of T1-weighted images before and after gadolinium contrast and T2-weighted images. Both these sequences can be obtained with or without different forms of fat suppression. The use of gadolinium contrast is controversial[10].

T2 TSE has been used extensively for imaging in rectal cancer[15-18]. It provides superb tumor-fat-neighboring tissue contrast. There are however other T2-weighted sequences that could replace traditional T2 TSE. Moreover 3D T2 TSE can perhaps replace all different imaging planes due to the possibility of multi-planar reconstruction and reformatting (MPR)[9,19]. In the following we put this to the test for assessment of fistula-in-ano. The main purpose of this study is to compare 3D TSE with 2D TSE. However, we also compared different T2 weighted sequences with each other, different T1 weighted sequences after intravenous Gadolinium administration with each other, and finally the T1 and the T2 sequences were compared to one another.

**MATERIALS AND METHODS**

Thirty nine consecutive patients (mean age 40 years; range 10-85 years, 22/17 male/female) with the request for MRI of fistula-in-ano were included in this prospective clinical trial. The study was approved by the local ethical committee and informed patient consent was obtained.

***MRI protocol***

Pelvic MRI-examinations were performed on a 1.5 T systems (Philips Intera, Best, The Netherlands) using either a four-channel cardiac phased-array coil (Philips, The Netherlands). According to our routines an anti-peristaltic agent is administrated prior to examination (normally Glucagon 1 mg intramuscularly, unless contraindications are present when Buscopan is administered). The images are started with T2 weighted images and concluded with T1 weighted images before and after intravenous gadolinium contrast agent (Dotarem) in standard dose. Usual contraindications to contrast agents and MRI are applied. The sequence variables are almost the same regarding slice thickness (3-5 mm), gap (0-1 mm), matrix (256-520, 256 for T1WI and 512 for T2WI) and field of view (250-300 mm). Only the 3D T2 TSE is performed with slice thickness of 1-2 mm. TR and TE are mentioned for each sequence separately as outlines below.

**T2 weighted sequences:** (1)2D T2 TSE or two dimensional turbo-spin-echo is performed in three planes, sagittal, oblique axial (perpendicular to anal canal), and oblique coronal (parallel to anal canal). TR is 4000-5000 ms, TE 120-130, and FA (flip angle) 90 degrees;(2) 3D T2 TSE. VISTA is the name of sequence for Philips vendor, while it is called SPACE in Siemens and CUBE in GE. VISTA (Philips, Netherlands) stands for Volumetric ISotropic T2w Acquisition. TE is 275 ms, TR 1500 ms, and FA 90 degrees. For rectal cancer we use 3D T2 TSE in sagittal plane, however for fistula-in-ano the imaging plane is perpendicular to anal canal; (3) STIR or short tau inversion recovery was applied with a TR of 1500 ms and TE of 15; and (4) T2 TSE with fat saturation was performed with a TE of 70 ms and TR of 2500 ms.

**T1 weighted sequences**: These sequences were performed the same way before and after intravenous gadolinium contrast agent administration: (1) 3D T1 weighted prepared gradient echo sequence with fat saturation (THRIVE) was used with a TR of 16 ms and TE 8 ms. FA = 10 degrees. THRIVE is the name Philips vendor uses; the corresponding sequence in Siemens is VIBE and LAVA in GE; and (2) 2D T1 fat saturation or SPIR has a TR of 9 ms and TE of 4-5 ms. The FA is 10 degrees. The acquisition times were between 4 and 6 min each (6 min for 3D T2 TSE).

***Image analysis***

Only axial/oblique images are compared to each other. One radiologist (MRT) with more than 10 years of experience in pelvic imaging assessed each sequence separately and blindly. The extension of each fistula tract was noted in regard to pelvic landmarks (pelvic floor, sphincter muscles, ischioanal fossa), internal openings (location clockwise, as well as height in regard to dentate line), and signs of activity (fluid-filled channels or avid contrast enhancement).

***Reference test***

The reference test comprised of surgical findings (25 cases), follow-up, EUS findings (21 cases) and assessment by an independent experienced radiologist (HA) with access to all sequences (all cases) whenever findings when findings were incongruent.

***Statistical analysis***

The results were dichotomized based on detection of all fistula tract, correct assessment of internal opening (clockwise +/- 1, and height wise +/- 1 cm), and detection of inflammation. Cohen’s kappa was measured based on comparison to set of reference tests. Agreement levels were defined as follows: poor (less than 0.2), fair (≥ 0.2 but < 0.4), moderate (≥ 0.4 but < 0.6), good (≥ 0.6 but < 0.8), strong (≥ 0.8 but < 0.95) and perfect (≥ 0.95).

**RESULTS**

A total of 56 fistula tracts were found in these patients. Two patients had only simple inter-sphincteric fistulae. The remainder 37 had trans-sphincteric tracts, of which 13 had simple tracts. Ten patients had an additional tract or abscess to the trans-sphincteric tract and 14 had multiple tracts. The results of comparisons between sequences is mentioned below and summarized in Table 1.

***Comparison between T2 weighted sequences***

The best T2 weighted sequence for depiction of fistula tracts was 2D T2 TSE where agreement levels for fistula tract depiction was perfect (Cohen’s kappa = 1.0). 3D T2 TSE showed 0.88 agreement for characterization of fistula tracts (*i.e.*, strong agreement; Figure 1). Both STIR and T2 with fat sat showed worse agreement levels with Cohen’s kappa of 0.19 (poor agreement) and 0.54 (moderate agreement), respectively (Figure 2). The internal openings showed somewhat less agreement on 2D TSE (Cohen’s kappa 0.88, defined as strong agreement) and with 3D T2 TSE 0.70 (good agreement). Cohen’s kappa was 0.31 for STIR (fair agreement), and 0.54 with T2 with fat saturation (moderate agreement). Detection of inflammation was concordant with Cohen’s kappa being 0.88 with 2D T2 TSE (strong agreement), 0.62 (good agreement) with 3D T2 TSE, 0.63 with STIR (good agreement) and 0.54 with T2 with fat saturation (moderate). STIR, 3D T2 TSE and T2 with fat saturation did not contribute in any case compared to 2D T2 TSE (Figure 3).

***Comparison between different post contrast T1 weighted sequences***

Post contrast 3D T1 weighted prepared gradient echo sequence with fat saturation (THRIVE) showed better agreement in depiction of fistulae (Cohen’s kappa = 0.94 or strong agreement), finding the inner opening (Cohen’s kappa = 0.97 or perfect agreement) and evaluation of inflammation (Cohen’s kappa = 0.94 or strong agreement) compared to post contrast 2D T1 fat saturation or SPIR where the corresponding figures were 0.71 (good agreement), 0.66 (good agreement) and 0.87 (strong agreement), respectively (Figure 4).

***T1 versus T2 weighted images***

Comparing the best T1 and T2 sequences, *i.e.*, 2D T2 TSE with 3D T1, showed that for best results, both sequences were necessary (see the figures above). While 2D T2 TSE was slightly better for determination of fistula extension, 3D T1 enabled better depiction of inner opening and inflammation (Figures 5 and 6).

**DISCUSSION**

This study is one of the few studies that examine MRI protocol for characterization of fistula-in-ano. We observed that among T2 sequences, 2D TSE provides the best evaluation. We and other authors[10,13] were hoping that 3D T2 weighted TSE might be able to replace 2D TSE. We were however unable to find support for this and as a result have abandoned 3D TSE after our evaluations.

The use of T1 weighted imaging is somewhat controversial. Several works have looked into this[20-22]. Most of these works have looked at role of contrast-enhancement for evaluation of presence or degree of inflammation. To our knowledge there has never been any published work on which T1 sequence should be used. In our study we did not subject each patient to both types of T1 weighted sequences but actually half of patients imaged with different types. Despite recommendation of some authors[11], we found THRIVE to give better results. We were not surprised that post-contrast imaging was superior in depiction of active inflammation. We were however surprised that THRIVE enabled better depiction of internal openings[23]. Our results suggest that contrast-enhanced T1 weighted imaging is beneficial.

Our study suffers several disadvantages. We did not have many cases, even though in radiologic literature concerning fistula-in ano our figures are not small. Also we had only one blind radiologist who evaluated the images. It would have been better if more radiologists had assessed the images blindly.

In our study we have used a novel method to compare different sequences. We did not look at sensitivity and specificity in diagnosis of fistula-in-ano. A recent meta-analysis looking into this from 2012 found the degree of heterogeneity between studies to be high and sensitivities being reported between 0.63 to 0.93, while the figures for specificity were 0.51 to 0.82[24].

The numbers of sequences that could be employed are many and several of them were not assessed by us. A recent Japanese study[25] had employed diffusion weighted imaging in 24 patients for assessment of disease activity and found it a feasible method. They had employed b- values of 0 and 1000. Not using gadolinium is of course an interesting option which basically diminishes the semi-invasive character of post contrast MRI. A Turkish study[26] employed a similar approach for comparison of sequences in depiction of fistulae in 26 patients. They however only compared 2D TSE, STIR and post contrast 2D T1 weighted echo fast low angle shot images (FLASH). Sequences such as 3D imaging were not used. They however came to the same conclusion that both T2WI and post contrast T1WI are necessary.

Both 2DT T2 weighted imaging and contrast-enhanced 3D T1 weighted prepared gradient echo sequence with fat saturation seem necessary for adequate depiction of fistula course, its internal opening and presence of active inflammation.

**COMMENTS**

***Background***

Treatment of fistula-in-ano requires careful assessment of extension and activity of fistulae. MRI has emerged as the dominant method for such assessment especially the more complicated fistulae. The sequences available are many and the values of these sequences have not been tested against each other and for different properties of fistula-in-ano.

***Research frontiers***

To test different MRI sequences for best depiction of extension, the internal openings and inflammatory activity of fistula-in-ano.

***Innovations and breakthroughs***

The authors tested old and new sequences against each other. We found out that T2 TSE with its best depiction of sphincter muscles is essential and necessary for assessment of extensions in fistula-in-ano. Contrary to hopes that 3D T2 TSE would replace 2D T2 TSE we found 3D TSE not able to add anything of value or capable of replacing 2D T2 TSE. Fat saturated T2-weighted sequences and STIR were inferior to T2 TSE. Surprisingly, post contrast T1 weighted imaging proved necessary for finding internal opening(s) or evaluation of inflammation activity. There was also differences between different post contrast T1 sequences with post contrast 3D T1 weighted prepared gradient echo sequence with fat saturation providing the best results.

***Applications***

This study outlines that 2D TSE and post contrast 3D T1 weighted prepared gradient echo sequence with fat saturation are enough and necessary.

***Terminology***

Fistula-in-ano is defined as presence of fistulae (abnormal channels hollow body organs in this case anorectal lumen and usually skin), sinus (blind channels), and their sequelae and nearby abscesses without any shown contact to anorectal lumen.

***Peer review***

The authors evaluate different MRI sequences (T1, T2, 3D) for assessing fistulas in MRI in 39 patients. An excellent paper, which really was necessary for daily routine radiology. Clear message, short overview of literature.

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**P-Reviewers:** Liu YY, Metwalli ZA, Razek AAKA, Schreyer AG**,** Sijens PE

**S-Editor:** Ji FF **L-Editor: E-Editor:**

**Table 1 Results of different magnetic resonance sequences and their agreement (Cohen’s kappa) to reference tests in depiction of different components of fistula-in-ano**

|  |
| --- |
|  |
| Sequence | Tract extension | Internal opening | Active inflammation |
| T2 weighted |  |  |  |
| 2D TSE | 1.0 | 0.88 | 0.88 |
| 3D TSE | 0.88 | 0.70 | 0.62 |
| STIR | 0.19 | 0.31 | 0.63 |
| 2D TSE with fat sat | 0.54 | 0.54 | 0.54 |
| T1 weighted |  |  |  |
| 3D T1 weighted with fat saturation | 0.94 | 0.97 | 0.94 |
| SPIR | 0.71 | 0.66 | 0.87 |

2D: Two dimensional; 3D: Three dimensional; TSE: Turbo spin-echo; STIR: Short tau inversion recovery; SPIR: Spectral presaturation with inversion recovery.

**Figure 1 Two different patients imaged with both 2D (images A and C) and 3D T2** turbo spin-echo **(B and D) images.** In most patients such as the 30 years old male with intersphincteric fistula (black arrows) depicted well depicted on both 2D (A) and 3D (B). However, in the 39 years old male depicted on images c and d the fistula (white arrows) as it enters dorsally was noticed only on 2 D images (C) and not 3D (D). Note that there is a seton partially visible inside the tract on 2D image.

**Figure 2 45 years old female imaged with** short tau inversion recovery **(A), 2D T2** turbo spin-echo **(B and D) and T2 with fat saturation (C).** The small vessels mask the exter-sphincteric fistula (white arrows) corrected noticed on T2 TSE. T2 with fat sat (C) was unable to detect the fistula or correctly identify its relationship to the sphincter complex (D).

**Figure 3 18 years old male with complex fistula that has two tracts (black arrows).** Demonstration of these tracts for the surgeon on both oblique axial (A) and sagittal 2D TSE images (B) is more difficult perhaps than a reformatted 3D T2 TSE image (C). TSE:Turbo spin-echo.

**Figure 4 Two male subject, one 39 years old (A and B) and one 52 years old (C and D) imaged with 3D T1 with fat saturation (A and C) and T1** turbo spin-echo **with fat saturation (B and D).** The 39 years old male (A and B) has an intersphincteric fistula treated with seton (white long arrows). Both the fistula and seton both the part inside the fistula and the luminal part (short arrows) are seen better on 3D images. The 52 years old has a small intersphincteric abscess cavity (white arrows C and D), shown well on both sequences. However the contrast between fat and muscle is much less on TSE compared to 3D T1 making it much easier to appreciate correctly the relationship between fistula/abscess and the surround sphincter.

**Figure 5 20 years old with intersphincteric fistula (white arrows) treated with seton image.** A: 2D T2 turbo spin-echo; B: 3D T1 weighted prepared gradient echo sequence with fat saturation. The seton is seen clearly on THRIVE as well as the inflammation, but not on T2. However the intersphincteric course of the fistula is clearer on T2 while the extent of inflammation obscures the thin external sphincter.

**Figure 6 45 years old female with fistula extending above the levator ani muscles (supralevator) and forming an abscess (white arrows).** The signal intensity of the fat and fluid are the same on T2 without fat saturation, and the abscess can easily be missed on T2 weighted images (A). However, the marked inflammation on 3D T1 post contrast clearly demonstrates the abscess (B).