# ACCURACY OF TRANSPERINEAL ULTRASOUND RELATIVE TO MAGNETIC RESONANCE IMAGING IN EVALUATION OF PERIANAL FISTULAS

Salah Mohammed Fateh [a]

Submitted: 5/3/2016; Accepted: 1/8/2017; Published: 15/8/2017

## ABSTRACT

### *Background*

Ano-rectal fistula is a chronic inflammation of perianal tissues affecting 1/10.000 individuals. Traditionally, treatment is surgical with the possibility of recurrence reaching up to a quarter of cases, therefore preoperative appropriate evaluations and imaging are necessary to decrease recurrence rate.

### *Objectives*

Determining accuracy of transperineal ultrasound relative to magnetic resonance imaging in evaluation of perianal fistulas.

### *Methods*

A prospective study was conducted on 51 patients with clinically diagnosed perianal fistula. Transperineal ultrasound (TPUS) and magnetic resonance imaging (MRI) were done for all patients. The following variables were recorded by each of the tests and the results were compared one to one: Firstly the number of the tracts, their relation to the anal sphincters. Secndly the number of internal openings, their sites and distances from the anal verge. Thirdly any associated findings, including perianal abscess, extension (branching) or local inflammatory phlegmons. Descriptive statistics were used. P-values $\leq 0.05$ were considered statistically significant.

### *Results*

Relative to the MRI, the accuracy of TPUS in detection of fistula tract was 96%. Finding of at least one relation of the tract to the anal sphincter was 86.7%, detection of internal opening was 82%, and localization of the internal opening was 82% with comparable result in measuring their distance from the anal verge (P value = 0.15). Lastly the overall accuracy of TPUS to find at least one associated finding was 92%. Among detected associated findings, TPUS was able to accurately classify them with no significant difference between TPUS and MRI (P-Value > 0.05). Three superficial fistula tracts were detected by TPUS and proved by surgical operation while they were undetectable by MRI.

### *Conclusion*

TPUS is an accurate imaging investigation in the evaluation of perianal fistula and its results was comparable to those of MRI in preoperative assessment of perianal fistula diseases.

**Keywords**: *Perianal fistula, Transperineal ultrasound, Magnetic Resonance Imaging.*

[a] Department of Surgery, College of Medicine, University of Sulaimani, Sulaymaniyah, Iraq.
Correspondence: salah.fatih@univsul.edu.iq

https://doi.org/10.17656/jsmc.10114

## INTRODUCTION

Ano-rectal fistula is a chronic inflammation of perianal tissues with a tract connecting skin of the perineum to the anal canal [1]. It affects approximately ten individuals in every 100,000. Men are affected two- to four-times more commonly than women, the reason is thought to be partially due to higher abundance of anal glands in male [2]. Infection of the anal glands and crypts is thought to be the commonest cause of fistula formation. The disease usually begins as an abscess, and in chronic stages it develops into a fistula in 60% of cases [3]. Traditionally; treatment has been surgical, with recurrence happening in up to a quarter of cases [4].

### *Anatomy of the Anal Region*

To understand the surgical options for treating fistulous disease, one must first consider the anatomy and function of the anal sphincters (Figure 1). The internal sphincter is involuntary and is composed of smooth muscle, continuous with the circular smooth muscle of the rectum. It is responsible for 85% of resting anal tone. In most individuals, it can be divided without causing a loss of continence. The external sphincter is composed of striated muscle and is continuous superiorly with the puborectalis and levator ani muscles. It contributes only 15% of resting anal tone, but its strong voluntary contractions resist defecation. A division of the external sphincter can lead to incontinence [5].

MRI and TPUS can show normal anal anatomy and perianal soft tissue with considerable amount of clarity (figure 2 and 3).

Based on MRI examination, St. James University Hospital classified perianal fistulae into five grades and relates the Parks surgical classification to anatomy seen at MR imaging in both axial and coronal planes [5]. The classification is based on relation of fistula tracts to the anal sphinecteres and presence of any possible associated findings including extension (branching) or abscess collection. Because of high chance of the disease recurrence after operation, especially in complex type perianal fistulae, preoperative comprehensive imaging is necessary in order to develop adequate treatment strategies and evaluate treatment outcomes [6].

Various imaging techniques have to surpass the accuracy of clinical examination, including, conventional fistulograhy, computed tomography, endo-anal sonography and MRI. Among them, MRI is regarded as the examination of choice, because its results have greater concordance with surgical findings than does any other imaging evaluation. It can demonstrate fistulous tracks and their relations to the anal sphincter complex, ischo-rectal fossa, and levator plate and it can show anovaginal or presacral diseases and evaluate whole pelvic region as well [5, 7, 8]. However, it lacks the real time capacity of ultrasound and the high resolution of high frequency linear ultrasound probes, beside these, it is not wildly available, time consuming and costly investigation [9]. In view of limitations mentioned above, there is a need for a simpler, less expensive, easily available, and repeatable method that can adequately evaluate perianal fistulas and its associated findings .TPUS may hold such promise [10, 11]. Rubens et al [12], described TPUS as a valuable tool for imaging perianal inflammatory disease and Maconi G, et al [13], found good relation between TPUS and MRI in assessment of perianal crohn's diseases.

The aim of the current study was to determine accuracy of TPUS relative to MRI in evaluating perianal fistulas based on three predetermined diagnostic categories; 1. Number of the tracts and their relation to the anal sphincters. 2. Number of internal openings, their sites and distances from the anal verge. 3. Any associated findings, including perianal abscess, extension (branching) or local inflammatory phlegmons.

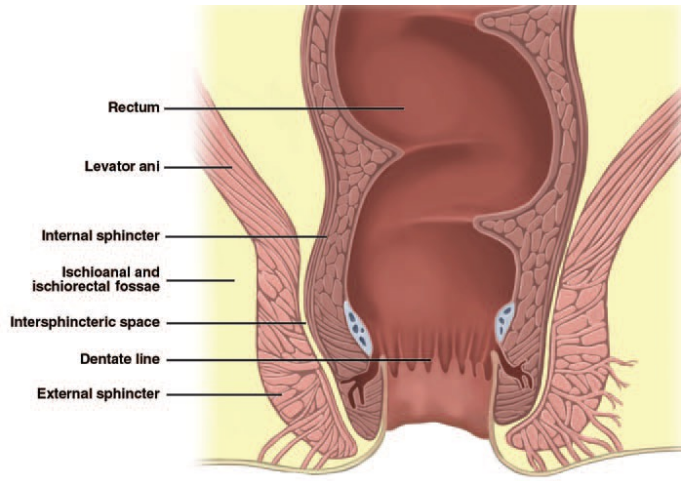


**Figure 1. Coronal illustration shows normal anal anatomy** [14]

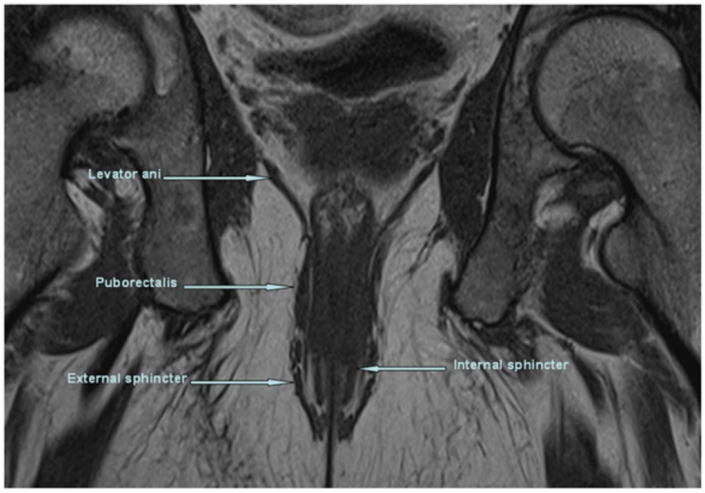


**Figure 2. Coronal T1WI MRI, showing normal anal anatmoy** [15]

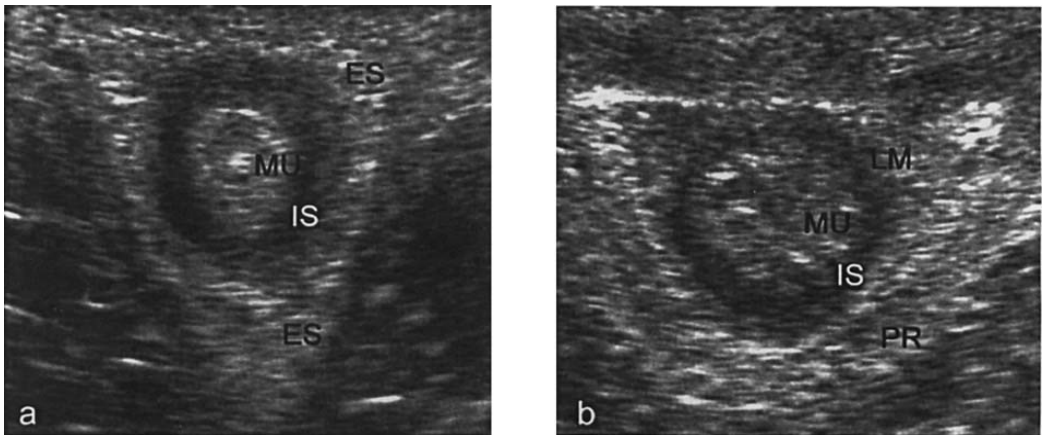


**Figure 3. TPUS ;Axial images of the normal anal sphincter complex: (a) mid-portion; (b) proximal part. The internal anal sphincter (IS) appears as a hypoechoic circle surrounded by the hyperechoic external anal sphincter (ES). MU = mucosa and submucosa, LM = longitudinal muscle, PR = puborectalis muscle. (The top of the image indicates the anterior part of the sphincter)** [16]

## METHODS

### *Study design*

This was a prospective study, conducted on 51 patients from October 2013 to January 2016. All patients were referred by specialized surgeons while they were clinically diagnosed as perianal fistula. TPUS examination was done in outpatient clinic while the procedure was explained to the patients and verbal consent was obtained. Then after time interval ranged between 1-10 weeks from the TPUS, MRI was done for them in Shar Teaching Hospital /Sulaimani/ Iraq. Both TPUS and MRI examinations were conducted by the same specialized radiologist with more than five years experience in imaging of perianal inflammatory diseases while he was semi blind to the patient's results, as MRI finding was recorded in separate case sheets without reviewing previously filled ultrasound case sheet for every patient.

### *Examination protocols*

TPUS examination was done, using Medison 2.00, SONOACE X8 ultrasound machine with multi frequency 7-12 linear probe. The patients were asked to lay down in left anterior oblique position with flexed knees, protruding his or her anus out while separating buttocks by putting his or her right hand on the right gluteal region and pulling it up .Visual inspection was done, numbers and sites of external openings as well as their distance from the anal verge were identified, then TPUS examination was done using probe covered by latex gloves filled with coupling gel, cross sectional image obtained in both sagittal and axial planes to anal canal to identify normal anatomical structures of anal canal, then cross sectional images where obtained along the line of the fistula tracts and perianal soft tissue as well .

The following information where recorded on case sheets;

1. Number of the tracts and their relation with anal sphincters (whether intersphincteric, trans-sphincteric, supra or extra-sphincteric)

2. Number of internal openings, their sites and distance from the anal verge. For determining site of the internal opening, anal o'clock was used, which is the surgeon's view of the perianal region when the patient is in the lithotomy position. The anterior perineum is at the 12 o'clock position, and the natal cleft is at the 6 o'clock position; 3 o'clock refers to the left lateral aspect, and 9 o'clock refere to the right lateral aspect of the anal canal. This schema exactly corresponds to the orientation of axial MR images of the perianal region [5]. (figure 4).

3. Any associated findings, including perianal abscesses, extension (new branching of the original tracts) or local inflammatory phlegmons.

Then MRI was done by using 1.5 Tesla, SIGNA HDxt GE MRI machine using body coil 3 mm slice thickness T2 FSE sequence obtained in three planes (axial and coronal oblique as well as sagittal) while the axial plane perpendicular to and coronal plain parallel to the anal canal length, and fat suppression T2WI were done in axial and coronal planes. In patients with suspected perianal abscess and features of acute inflammatory process in the perianal fat, pre and post contrast enhanced fat suppressed T1-weighted images were obtained as well as in both axial and coronal plane, the contrast given via IV infusion using 1mmole/Kg gadolinium DPTA. The above-mentioned variants were recorded again on separate case sheet depending on MRI findings while reader was blind from recorded information of previously done TPUS. Finally, the result categories from both TPUS and MRI were compared one-to-one for every patient.

It is important to mention that the diagnosed criteria for above variant in both modalities were as follows; fistula tracts were diagnosed when an elongated tubular channel identified (hypoechoic by US and hypo intense T2 WI MRI ) with presence of fluid or gas echo or signal intensity within it in both modalities respectively .

Relation of the tracts was determined using St. James University Hospital classification of perianal fistula [5], (figure 5). Internal openings were identified as the tract traversing internal sphincter while abscesses were diagnosed as localized fluid collection with more than 10 mm in diameter in the perianal region. Branching (extension) was diagnosed when a secondary tract arising from the primary one and seen either in the ischo-anal fat or within intersphincteric plane. Inflammatory phlegmone was diagnosed based on detection of perianal fat edema with or without associated abscess collection .

One of the pitfalls was in differentiation of the active tract from scarring, as both having relatively the same imaging appearance, while they can be differentiated by presence of fluid or gas shadows within the tract by imaging and from history of discharge at the time of examination which indicate disease activity rather

than the scarring. Although some authors suggest injection of saline or contrast media through external opening before doing examination, but as general it is inapplicable and difficult to be performed, on the other hand, active tract almost always contains some fluid or gas which they can be well-detected by both TPUS and MRI .

### *Statistical analysis*

Statistical Package for Social Sciences (SPSS) version 22, and Microsoft excel spreadsheets (2013) were used for data entry, calculations, and data interpretations. Descriptive statistics were used in the evaluations. *P*-values $\leq 0.05$ were considered statistically significant.

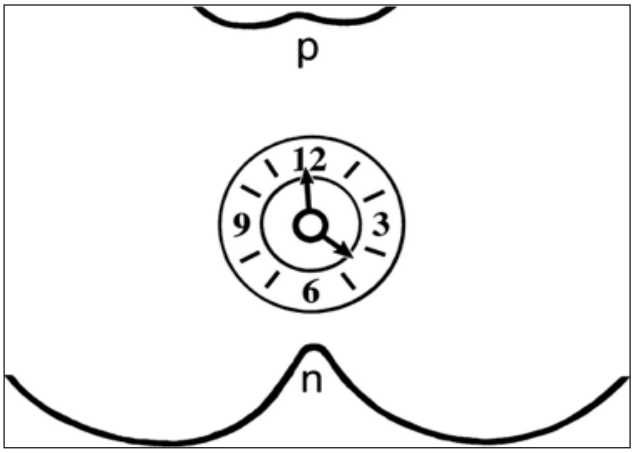


**Figure 4. MRI axial section showing anal oclock , Drawing illustrates the anal clock, which is the surgeon's view of the perianal region when the patient is in the lithotomy position. The anterior perineum (p) is at the 12 o'clock position, and the natal cleft (n) is at the 6 o'clock position; 3 o'clock refers to the left lateral aspect, and 9 o'clock, the right lateral aspect of the anal canal. This schema exactly corresponds to the orientation of axial MR images of the perianal region [5].**

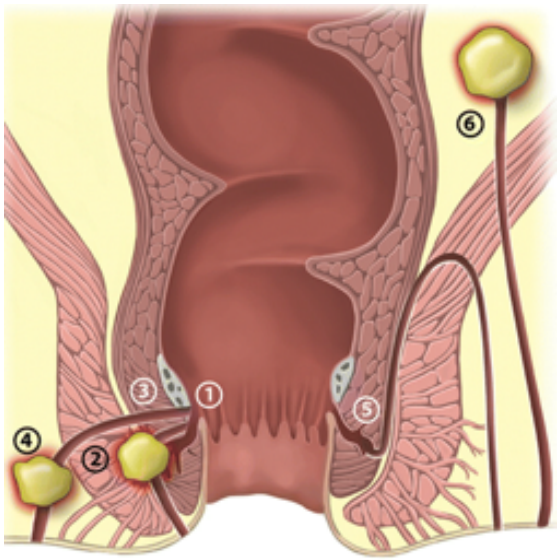


**Figure 5. Coronal illustration shows types of perianal fistulas according to St. James classification. Simple intersphincteric (1) and intersphincteric with abscess (2) fistulas are both confined by external anal sphincter, whereas simple transsphincteric (3) and transsphincteric with abscess (4) fistulas both involve ischiorectal or ischioanal fossae. Extension above levator ani characterizes supralevator fistulas, such as suprasphincteric fistulas (5), which arise from anal canal before ascending to supralevator space, and extrasphincteric fistulas (6), which result from pelvic infection extending inferiorly across levator ani and do not involve anal sphincter complex. (Drawing by Nowak C) [17].**

## RESULTS

The study included 51 participants with mean age of 37.2 years, ranged 15 to 67 years. Forty two (82%) male and 9 (18%) were female. The mean time interval between conducting TPUS and MRI imaging was 3.6 weeks, ranging from 1 to 10 weeks.

### *1-Regarding tracts*

#### *1.1 Detection*

TPUS was able to detect 53 (96%) out of 55 tracts found by MRI with sensitivity of 96% and in comparison with MRI result, PPV of TPUS was = 100% and over all accuracy was 96%. Table 1 shows that majorities of patients in both TPUS and MRI have a single tract, and there was no significant difference in number of tracts detected per patient in both TPUS and MRI (P-Value > 0.05).

#### *1.2 Classification of tracts in relation to anal sphincters.*

Among 53 tracts found by TPUS, TPUS was able to correctly classify and find at least one relation of the tracts to anal sphincters (either intersphincteric, trans-sphincteric, supra or extra-sphincteric) in 46 (86.7%), with sensitivity, accuracy and PPV of 86.7%,86.5% and 100% respectively.

Table 2 shows sensitivity, specificity, PPV, NPV and accuracy of TPUS regarding each type of relation of fistula tracts with anal sphincters.

### *2-Internal opening*

#### *2.1-Detection*

TPUS was able to correctly detect 46 (85%) out of 54 internal openings detected by MRI. Overall accuracy of TPUS in detection of internal openings was 82%, with sensitivity and positive predictive values of 85% and 100 % respectively.

#### *2.2 Localization site of internal openingsand their distance from the anal verge*

Using anal o'clock, accuracy of TPUS in determining the site of internal openings was 82% with a sensitivity of 87.5%. In the TPUS reports, the mean distance of the internal openings from the anal verge was 17.6 millimeters while in MRI results was 20.6 millimeters, and this was statically insignificant (p-value = 0.15)

### *3. Detection of possible associated findings*

Table 3 shows that among 27 associated findings which were seen by MRI, TPUS found 24 of them. So, regarding detection of at least one associated finding, TPUS had sensitivity, specificity, positive predictive value and negative predictive value of 88.8%, 93.5%, 92.5%, and 90% respectively and overall diagnostic accuracy of 93.5%. TPUS was able to accurately classify each sort of associated finding and there was no significant difference between TPUS and MRI results ( P-Value > 0.05).

**Table 1. Number of tracts detected by TPUS and MRI in each patient.**

| No. of tracts/patients | TPUS | % | MRI | % | P value |
|---|---|---|---|---|---|
| **1** | 43 | 88% | 44 | 90% | 0.75 |
| **2** | 5 | 10% | 4 | 8% | 0.72 |
| **3** | 1 | 2% | 1 | 2% | |

**Table 2. Diagnostic characteristics of TPUS regarding types of relation of fistula tracts with anal sphincters.**

| Relation to anal sphincters | Sensitivity | Specificity | Test Accuracy | Positive Predictive Value | Negative Predictive Value |
|---|---|---|---|---|---|
| **Intersphincteric** | 100% | 100% | 100% | 100% | 100% |
| **Transsphincteric** | 94.5% | 100% | 94% | 100% | 97% |
| **Suprasphinteric** | 0% | 100% | | | 87% |
| **Extrasphincteric** | 0% | 100% | | | 97% |

**Table 3. Diagnostic characteristics of TPUS regarding detected associated findings.**

| Associated Findings | TPUS | MRI | Sensitivity | specificity | Test accuracy | PPV | NPV | P-value |
|---|---|---|---|---|---|---|---|---|
| **Abscess** | 14 | 16 | 87.5% | 97% | 92% | 93% | 92% | 0.66 |
| **Branching** | 6 | 7 | 86% | 100% | 98% | 100% | 98% | 0.75 |
| **Inflammatory phlegmon** | 4 | 4 | 100% | 94% | 94% | 50% | 100% | |

## DISCUSSION

TPUS detected 53 (96%) tracts out of 55 tracts indentified by MRI with sensitivity of 96%, PPV= 100% and over all accuracy of 96%. TPUS did not show two tracts which were turned out by MRI to be complex fistulae in ano (one was supra-sphincteric, while the other was extra-sphincteric) and one of them was associated with an abscess while the other associated with both abscess and inflammatory phlegmon. This may be explained by the fact that there is limited penetration efficacy of high frequency probe (as used in the current study). On the other hand, associated active perianal inflammatory processes decrease patients compliance and make TPUS difficult because of local pain and tenderness.

From 53 tracts found by TPUS, relation of 46 (86.7 %) of them to the anal sphincters was accurately determined with overall sensitivity, accuracy and positive predictive value of TPUS in detecting at least one relation of the tracts to the anal sphincters were 86.7% , 86.5% and 100% respectively. It is important to mention that all (29/29) (100%) intersphincteric (figure 6) and almost all (17/18 tracts) (94%) of trans-sphincteric (figure 7) fistulae were correctly classified by TPUS.

TPUS was unable to classify seven tracts (13.3%) (Five supra-sphincteric, one extra-sphincteric and the other was trans-sphincteric). Among above unclassified cases, four (57%) of them were associated with an abscess and/or inflammatory phlegmon. This may be contributed by two factors; 1st local tenderness makes the examination difficult, and secondly, ischo-anal fat edema, due to local acute inflammatory process, decreases image resolution and penetration, the latter may explain the difficulty in examination of supra and extra- sphincteric fistulae which extend deep in the ischo-anal fat.

TPUS was able to correctly detect internal opening of 46 (85%) tracts out of 54 detected by MRI (figure 1 and 2) with sensitivity, and positive predictive values of 85% and 100 % respectively and over all accuracy of 82%. Among false negative eight cases, 6 of them

(75%) were opened into anal canal at a distance equal and more than 40 mm from the anal verge, and 4 (50%) of them were associated with either abscess or inflammatory phlegmon which might be regarded as the underlying causes of limitations and false negative results.

TPUS was able to localize the internal openings according to anal o'clock with sensitivity and accuracy of 87.5% and 82% respectively. Regarding measuring distance of internal openings from the anal verge, there was no significant difference between TPUS and MRI results (p-value = 0.15).

Twenty-nine (57%) patients had no associated findings in both TPUS and MRI, while 22 (43%) of patients had at least one associated finding in either TPUS or MRI examination. TPUS detected 24 out of twenty-seven associated findings detected by MRI. Regarding detection of at least one associated findings, TPUS shows sensitivity, specificity, positive predictive value and negative predictive value of 88.8%, 93.5%, 92.5%, and 90% respectively and with overall diagnostic accuracy of 93.5%. Besides, TPUS was able to accurately determine sorts of associated findings with statistically insignificant difference in between TPUS and MRI results (P> 0.05).

There were 3 associated findings, two abscesses (figure 8) and one extension (figure 6A and figure 8C), detected by MRI, while not seen by TPUS. On the other hand, in two other cases, there were associated findings (one abscess and other inflammatory phlegmon) by TPUS while they were not found by MRI. These differences between the two results might be due to time elapse in conducting both studies, when mean time interval between TPUS and MRI in the cases mentioned above was 4 weeks (2-6 weeks), which might be sufficient for change in characters of inflammatory processes (either going towards healing or more progression and complication).

It is important to mention that TPUS found 3 superficial tracts (tracts extending just under skin and opened in to anal canal by less than 5mm distance from the anal verge without any relation to the anal sphincters) (figure 9), but they were undetectable and unindentified by MRI, while their presence was proved by clinical examination and surgical exploration. This may show superiority of TPUS in detection of such tracts if compared to MRI, as high frequency linear probes have higher resolution than MRI for superficial lesions using ordinary body coils. However, further studies with higher statistical power might be necessary to confirm that.

There are several limitations for this study; first of all, ultrasound is an operator dependant tool and need special skill. The study was not totally blind, as both TPUS and MRI were conducted by the same radiologist, although each patient had separate case sheet for each modality, but the radiologist might have been sometimes preoccupied by the predetermined TPUS results during reading and interpretation of the MRI findings. Additionally, time interval between conducted TPUS and MRI could be another source of bias which, in some cases, reached up to 10 weeks. This might contribute to the incongruity between the results, especially in the evaluation of associated findings.

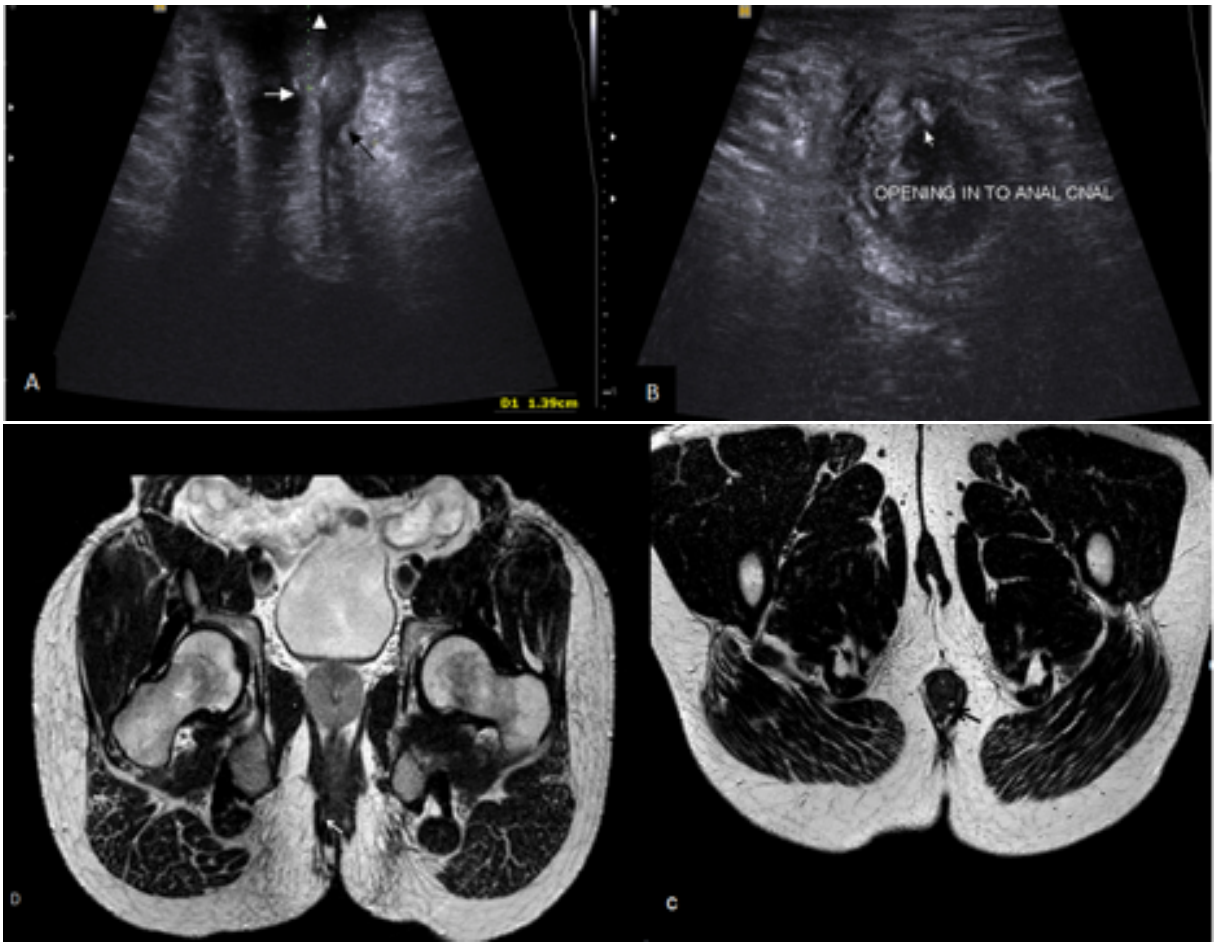


**Figure 6. Intersphincteric fistula in ano. 1- TPUS; A- sagittal section ; showing tract with internal opening (white arrow) and its desistance from anal verge (arrow head), Note branching of the tract in the intersphincteric plane below the line of internal opening, suggesting ramification (black arrow). B. axial section showing cross section of anal canal with fistula tract in the intersphincteric plane and its opening in to anal canal (white arrow). 2-T2WI MRI in axial (C ) and coronal (D) planes, showing intersphincteric fistula in ano (arrows).**

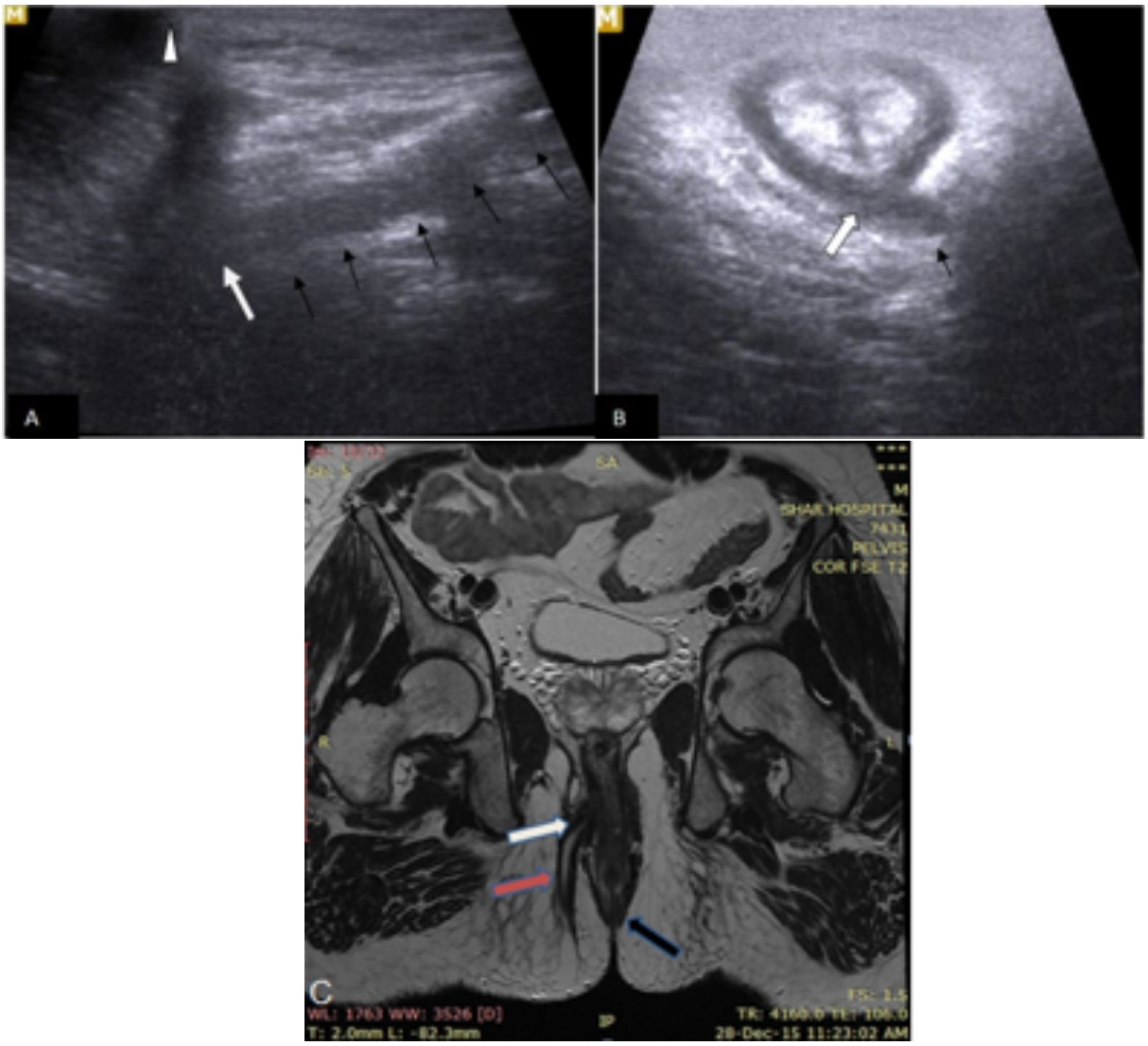


**Figure 7. Trans-sphincteric fistula in ano. 1- TPUS longitudinal and axial sections (A and B) along line of the tract (black arrows ) which is extended deep through ischo-anal fat and traversing external anal sphincter (white arrow) at a considerable distance from the anal verge (arrow head). 2- Coronal T2WI MRI; showing tract, (pink arrow) and site of traversing anal sphincters and internal opening (white arrow) at the considerable distance from the anal verge.**

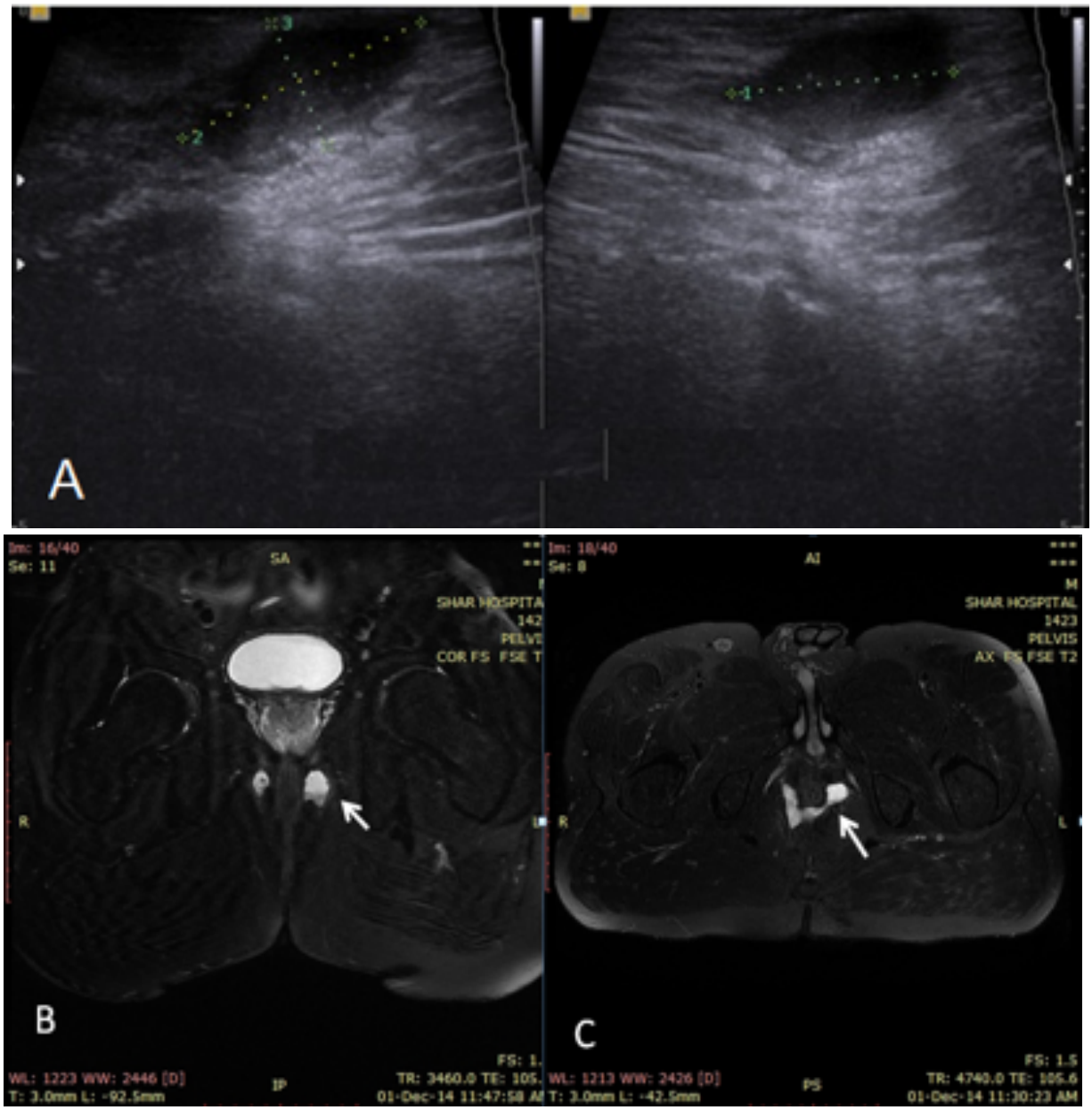


**Figure 8. Perianal abscess collection. A. TPUS, B and C.T2WI fat suppression MRI in coronal and axial sections, showing an abscess (A and B) as well as branching and U shaped extension (C) in the intersphincteric plane (arrows).**

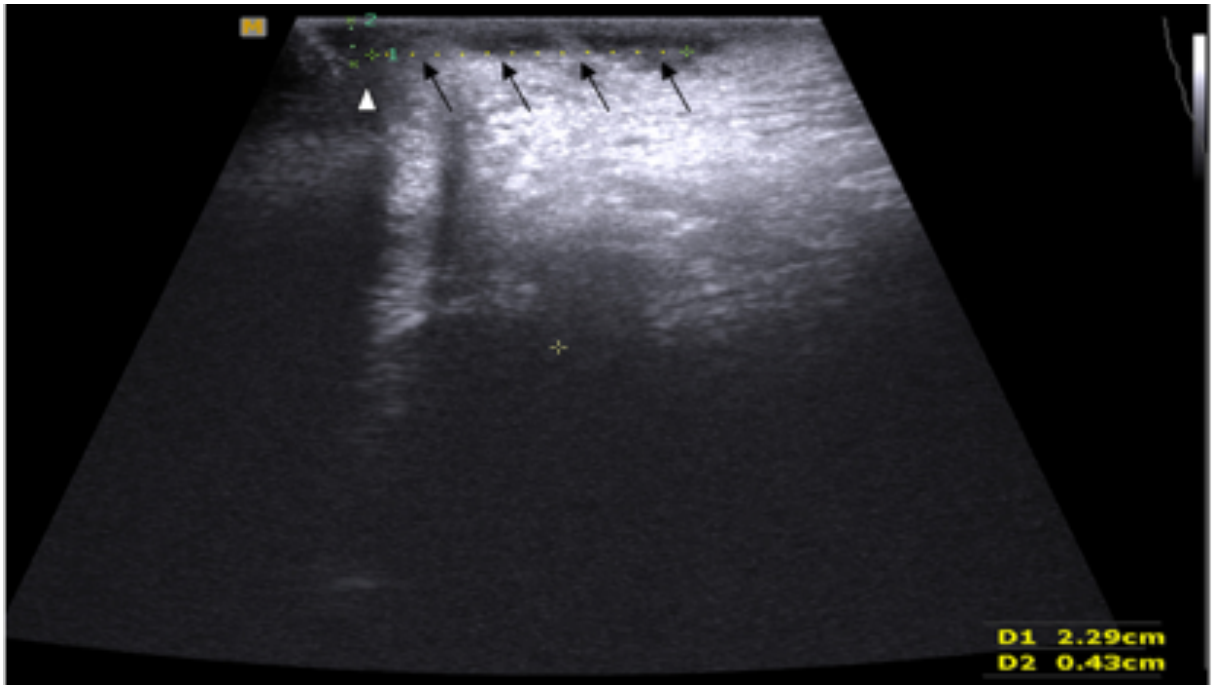


**Figure 9. Superficial fistula in ano, longitudinal section along line of the tract (arrows) with a tract extending superficially under skin and open in to anal canal. arrow head )at about to 4mm distance from the anal verge.**

In conclusion, TPUS has the ability to detect and characterize PAF and their possible associated findings with considerable amount of accuracy, comparable with that of MRI, and it can be used as a 1st line imaging investigation, as it is simple, non-invasive, quick, wildly available and with low cost effectiveness. However, MRI is being reserved for situations where TPUS is unable or difficult to answer findings in question, especially in cases of; A. Presence of associated findings, B. When the tracts extending deep and of high grade. TPUS has ability to detect superficial fistula tracts which are difficult, if not impossible, to be detected by MRI using ordinary body coil. This might suggest its use in new image-based classification of perianal fistula diseases, especially in older calcification, including St. James University Hospital and Parks classification, superficial fistulae were not included.

### *List of Acronyms and Abbreviation*

TPUS: Transperineal ultrasound, MRI: magnetic Resonance Imaging, PAF: Perianal Fistula

### *Delerations*

### *Ethics approval and consent to participate*

Selected topic was accepted by scientific and ethical committees of College of Medicine of Sulaimani University and official acceptance was taken from health authorities to conduct this study. The aim of the study was clarified to the participants and informed consent was obtained, while collected information were kept confidential.

### *Competing interests*

The author declares that has no competing interests

### *Trial registration*

The study retrospectively registered on December 03, 2016 with Research Registry Identifying Number 1929.

## REFERENCES

1. Waniczek D, Adamczyk T, Arendt J, Kluczewska E, Kozenska-Marek E. Usefulness assessment of preoperative MRI fistulography in patients with perianal fistulas. Pol J Radiol. 2011;76(4):40–4.

2. Lunniss PJ, Jenkins PJ, Besser GM, Perry LA, Phillips RK. Gender differences in incidence of idiopathic fistula-in-ano are not explained by circulating sex hormones. Int J Colorectal Dis 1995;10(1):25–28

3. Robinson AM Jr, DeNobile JW. Anorectal abscess and fistula-in-ano. J Natl Med Assoc. 1988; 80(11):1209–1213

4. Quah HM, Tang CL, Eu KW, Chan SY, Samuel M. Metaanalysis of randomized clinical trials comparing drainage alone vs primary sphincter-cutting procedures for anorectal abscess-fistula. Int J Colorectal Dis. 2006;21(6):602–609

5. Morris J, Spencer JA, Ambrose NS. MR imaging classification of perianal fistula and its implications for patient management. Radiographics 2000; 20(3): 623–35.

6. Parks AG, Gordon PH, Hardcastle JD. A classification of fistula-in-ano. Br J Surg. 1976; 63(1):1–12.

7. Barker PG, Lunniss PJ, Armstrong P, Reznek RH, Cottam K, Phillips RK. Magnetic resonance imaging of fistula-in-ano: technique, interpretation and accuracy. Clin Radiol 1994; 49(1):7-13.

8. Spencer JA, Ward J, Beckingham IJ, Adams C, Ambrose NS. Dynamic contrast-enhanced MR imaging of perianal fistulas. AJR Am J Roentgenol 1996; 167(3):735-741.

9. Jaime de Miguel Criado. MR Imaging Evaluation of Perianal Fistulas: Spectrum of Imaging Features, RadioGrahics. 2012; 32(1):175-194.

10. Jochen Wedemeyer, Timm Kirchhoff, Gernot Sellge, Oliver B, Joachim L, Michael G, et al. Transcutaneous perianal sonography: A sensitive method for the detection of perianal inflammatory lesions in Crohn's disease, World J Gastroenterol 2004;10(19): 2859-2863

11. Shilpa V. Domkundwar, Atul B. Shinagare. Role of Transcutaneous Perianal Ultrasonography in Evaluation of Fistulas In Ano, J Ultrasound Med 2007; 26(1):29–36.

12. Rubens DJ, Strang JG, Bogineni-Misra S, Wexler IE. Transperineal sonography of the rectum: anatomy and pathology revealed by sonography compared with CT and MR imaging. AJR Am J Roentgenol 1998; 170(1):637–642.

13. Maconi G, Tonolini M et al, Transperineal perianal ultrasound versus magnetic resonance imaging in the assessment of perianal Crohn's diseases, Inflammatory Bowel Diseases ,official journal of the crohn's & colitis foundation of America.2013;19(13):2737-2743.

14. Ryan B, Mahmoud M. Al-hawary, Ravi K Kaza, Ashish P.Wasnik, Peter S.Lui, et al. Rectal Imaging: Part 2, Perianal Fistula Evaluation on Pelvic MRI What the Radiologist Needs to Know, AJR Am J Roentgenol 2011;197(1): 204-220.

15. A. P. Sathe, E. Soh, K. Y. Seto et al, Magnetic Resonance Imaging of Perianal Fistulas, ECR 2014/C-0317. http://dx.doi.org/10.1594/ecr2014/C-0317.

16. Peschers UM, DeLancey JO, Schaer GN, SchuesslerB. Exoanal ultrasound of the anal sphincter:normal anatomy and sphincter defects. Br J Obstet Gynaecol September 1997; 104(9): 999-1003.

17. Ryan B., Mahmoud M. , Ravi K. et al , Rectal Imaging: Part 2, Perianal Fistula Evaluation on Pelvic MRI What the Radiologist Needs to Know, AJR Am J Roentgenol 2011;197: 204-220