

Original Research Article

Importance of high-frequency and low-frequency three-dimensional endoanal ultrasound scan in diagnosing perianal fistula and abscess

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ABSTRACT

Background: Three-dimensional endoanal ultrasound scanning (3D-EAUS) is the first line of investigation in the management of perianal fistula and abscess. High frequency (HF) and low frequency (LF) are 2 frequency modes in 3D-EAUS which have different resolutions and penetration depth. Our study aims to compare the 3D images of HF with LF modes.

Methods: This is a retrospective study of the 3D-EAUS images of patients with perianal fistula and abscess (perianal sepsis) who underwent 3D-EAUS from January 2019 to December 2020 in our hospital. The scans with both high and LF setting images were included in our study

Results: The 53 3D-EAUS images were randomly selected, out of them images with both HF and LF modes were included. The dimensions of both HF and LF 3D cuboid images were measured. The volume of tissue measured in HF and LF modes were 155 ml and 380 ml respectively. The LF images scored 22/24 points and the HF images scored 16/24 points.

Conclusions: LF and HF modes complement each other. LF mode can better delineate tracts and abscesses in extra-sphincteric space than HF mode. HF mode can better delineate tracts and abscesses in inter-sphincteric space as well as internal openings. We recommend routine use of both frequency modes while performing 3D-EAUS. Operating surgeons should gain expertise in performing the scan and reading the 3D image.

Keywords: Endoanal ultrasound, Perianal fistula, LF, HF

INTRODUCTION

The importance of three-dimensional endoanal ultrasound (3D-EAUS) in preoperative diagnosis of perianal fistula and abscess has been well established by various studies.¹⁻¹² It is considered a first-line investigation before MRI for simple perianal fistula and abscess.^{2-6,10} The limitation of 3D-EAUS compared to MRI in diagnosing these complicated cases is the depth of penetration of ultrasound waves and the resolution of the tissues which even differ between high-frequency and low-frequency ultrasound. Higher frequency waves produce high resolution with limited depth of penetration whereas lower frequency waves produce lower resolution with

greater depth of penetration.¹³ Though MRI is considered the gold standard investigation for diagnosing complicated perianal fistula and abscess it is time-consuming and has specific contraindications.^{1,6} 3D-EAUS has the advantage of being cheaper, short examination time, and with no major contraindications.¹ Current studies on 3D-EAUS have not focused on the two frequency settings (high and low) of the transducer in diagnosing perianal conditions. The frequency range of the B-K medical 2052 transducer ranges from 6-16 MHz. The HF setting (H) gives a better image of tissues close to the transducer whereas the low-frequency setting (L) gives a wider view of surrounding tissues.

In this study, we compared the 3D-EAUS images obtained by the HF mode with the low-frequency mode.

METHODS

This is a retrospective study of the 3D-EAUS images of patients with perianal fistula and abscess (perianal sepsis) who underwent 3D-EAUS from January 2019 to December 2020 in Apollo hospitals, jubilee hills, Hyderabad. 3D-EAUS was done in patients with perianal fistula and abscesses and the images were saved in the ultrasound machine. The scans with both high and low-frequency setting images were included in our study. As our study was based on frequency modes of a machine, ethical clearance was not required.

Ultrasound technique

The 3D-EAUS was done by fellows and consultants in the department of colorectal surgery along with clinical examination. The examination was performed with a B-K medical ultrasound transducer 2052 (B-K medical, Herlev, Denmark) with 360-degree rotating head, whose frequency ranged from 6-16 MHz connected to a BK Flex Focus 800 ultrasound machine. The transducer, after covering with a glove filled with ultrasound gel and lubricating the external surface, was introduced gently inside the anus with the patient in left lateral position. 3D images were obtained after pressing a specific button on transducer. Initially HF setting (13 MHz) was selected and a 3D image was obtained, later low-frequency setting (9MHz) was selected and a 3D image was obtained irrespective of the complexity of the fistula tract. We never used hydrogen peroxide for enhancement of the fistula tract. The 2 settings stored 3D-EAUS images and their reports were reviewed and analyzed by the 1st author after copying images to pen drive and then transferring them to computer with BK3D viewer program application. The ultrasound monitor with the probe is shown in Figure 1 and HF (H) and LF (L) settings on the monitor with frequency values are shown in Figure 2 A.



Figure 1: 3D-EAUS BK flex focus 800 monitor with 2052 transducer.

Interpretation of the 3D-EAUS image

In the normal 3D endoanal scan anatomy, the internal sphincter appears hypoechoic and the external sphincter appears mixed/hyperechoic. The low-frequency images are relatively hypoechoic compared to the HF images. The Fistula tract and abscess appear as hypoechoic tract and collections respectively. According to Cho criteria, the internal opening of the fistula tract is identified by criterion I-inter-sphincteric tract touching the internal sphincter without any defect or breach, criterion II-defect in the internal sphincter and criterion III- breach in the anal submucosa.¹⁴ Though not performed in our study, hydrogen peroxide instillation into the fistula external opening can better delineate the fistula as a hyperechoic tract.⁵ Volume render mode improves the localization of the fistula tract and internal opening.¹⁵ Posterior acoustic enhancement is an artifact seen in ultrasound of any fluid containing structures like distended gall bladder, cysts, abscess, etc.¹⁶ In 3D-EAUS the posterior acoustic enhancement due to fluid in the fistula tract or pus in the abscess cavity, the area beyond the hypoechoic area appears as a hyperechoic shadow and this feature differentiates between perianal abscess, fluid collections in fistula tracts with other hypoechoic areas like scar.

RESULTS

A total of 53, 3D-endoanal scans were randomly selected. Most of the scans were done in HF settings alone which were excluded and scans that had both LF and HF images were included. The 3D image formed is in the shape of a cuboid in both settings (Figure 2B).

The dimensions of the 13 MHz HF 3D cuboid and 9 MHz LF 3D cuboid were measured in our study. The average length, breadth and, height of the 13 MHz HF 3D-EAUS cuboid was 58mm, 52 mm and, 55 mm and for 9 MHz LF 3D-EAUS cuboid was 58 mm, 81 mm, and 83 mm respectively (Figure 3 A). This includes the central transducer hypo-echogenicity of a diameter of 16 mm. All values were average values measured.

The total volume measured by the 3D-EAUS for 13 MHz HF and 9 MHz LF cuboids were 165,880 mm³ and 389,934 mm³ respectively (Volume of cuboid=Length×breadth×). The volume of the central transducer cylinder ($V=\pi r^2 h$) is 11,666 mm³. By subtracting the volume of the cylinder from the total volume of the cuboid we get the effective volume of the tissue scanned which was 154,214 mm³ for 13 MHz HF mode, and, 378,268 mm³ for 9 MHz LF mode. So, the volume of tissue examined in the HF and LF settings were approximately 155 ml and 380 ml respectively.

The 13 MHz was the default HF setting at our center. The volume of tissue examined in LF mode (9 MHz) is 2.45 times higher than the volume of tissue examined in the HF mode (13 MHz). As the frequency of the 3D-EAUS increases, the volume of the tissue examined decreases.

For every 1 MHz increase in frequency, there is a reduction of the volume of tissue examined by nearly 56 ml.

Each frequency has the usual 3D mode, volume render mode (Figure 3 B), 4 up mode, and 6 up mode (Figure 4

A). In 4 up mode the 3D images are displayed in a 2-dimensional sagittal plane, coronal plane, axial plane, and combined 3 planes. 6 up mode is the combination of 4 up mode in addition to 3D mode and volume render mode. These different images can give a better view of the 3D anatomy of the perianal fistula and abscess.

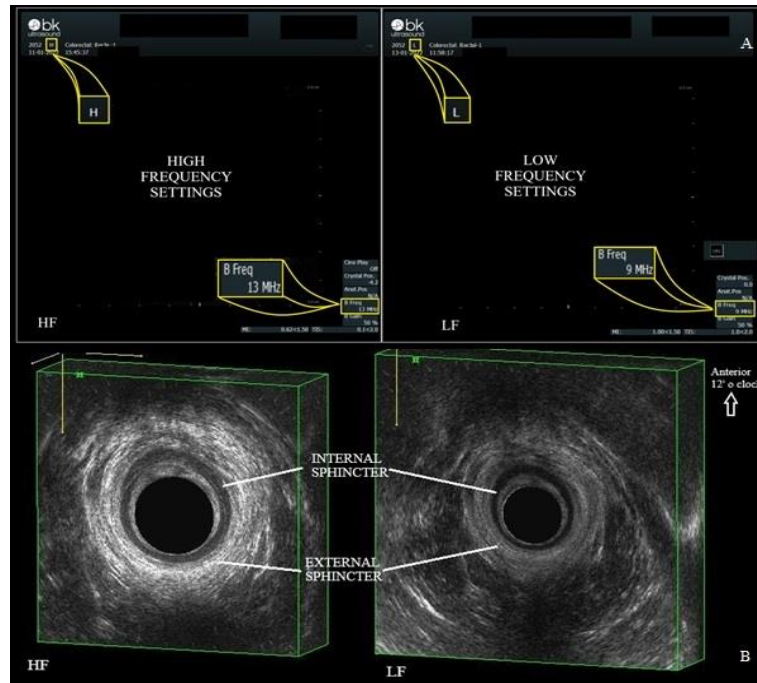


Figure 2 (A and B): HF H and LF L modes as displayed in the monitor. Normal 3D cuboid anatomy of HF with LF at mid anal level. The internal sphincter appears hypoechoic and external sphincter appears as a hyperechoic ring.

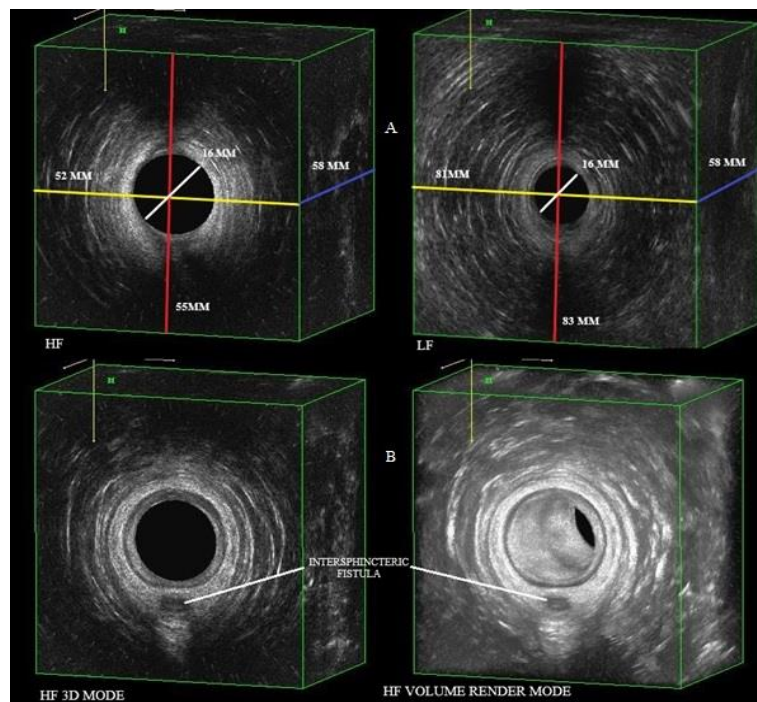


Figure 3 (A and B): 3A comparing the dimensions of HF and LF 3D cuboid. The blue line represents length, the yellow line represents breadth, and the red line represents height. The white line represents the diameter of the central hypoechoic of the transducer. Comparing the 3D mode with volume render mode of an intersphincteric fistula tract in HF setting.

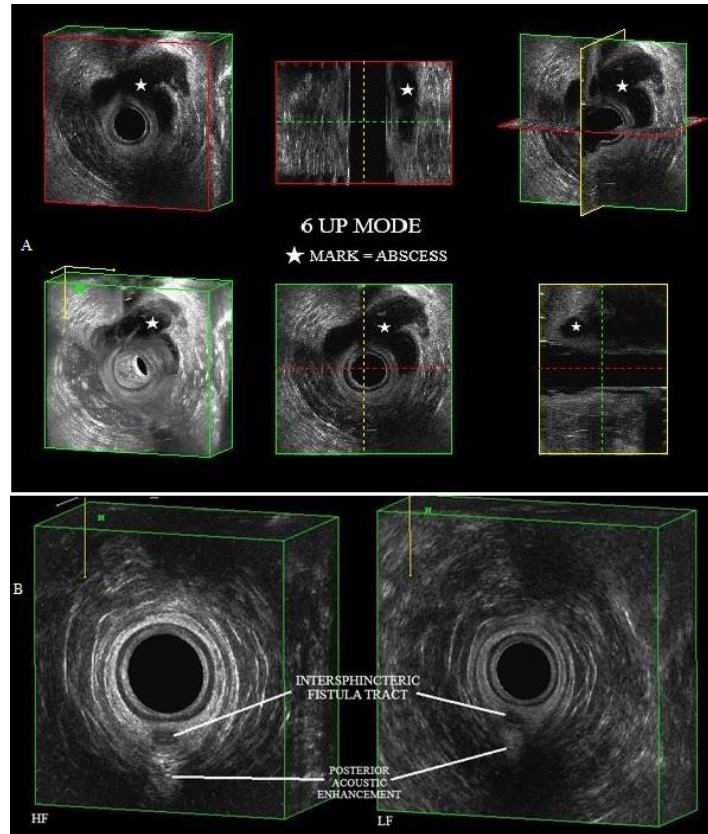


Figure 4 (A and B): 6 UP mode and posterior intersphincteric fistula tract with posterior acoustic enhancement (PAE) due to fluid in the fistula tract. As we can see in the HF image external sphincter is more hyperechoic than the LF image, and the hypoechoic fistula tract is more visible in the HF image than the LF image. PAE is seen in both images.

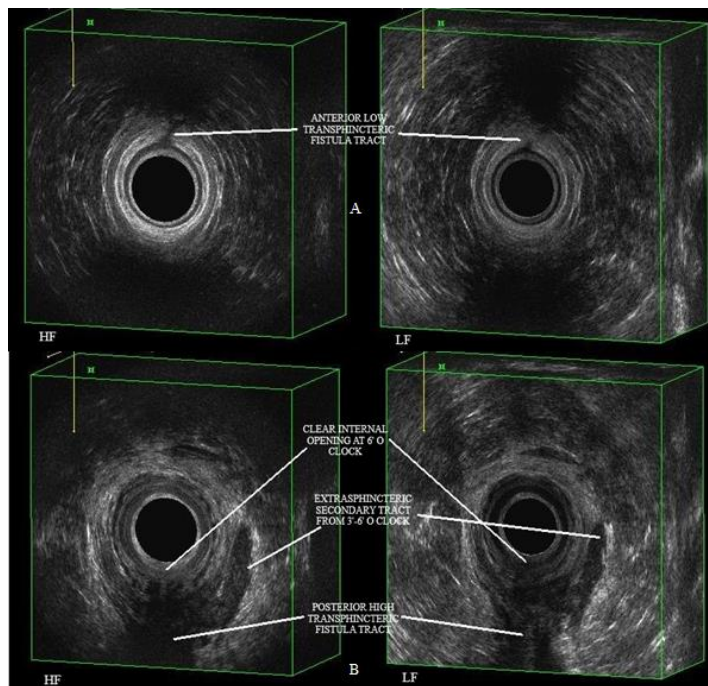


Figure 5 (A and B): An anterior low transsphincteric fistula with a tract more prominent in the HF image than the LF image with an internal opening at 12 o'clock (Cho criteria I). Posterior mid to high transsphincteric fistula with a clear internal opening at 6 o'clock (Cho criteria III) and a thick primary tract with a secondary extrasphincteric tract extending from 6 to 3 o'clock along with PAE. Both HF and LF images are clear.

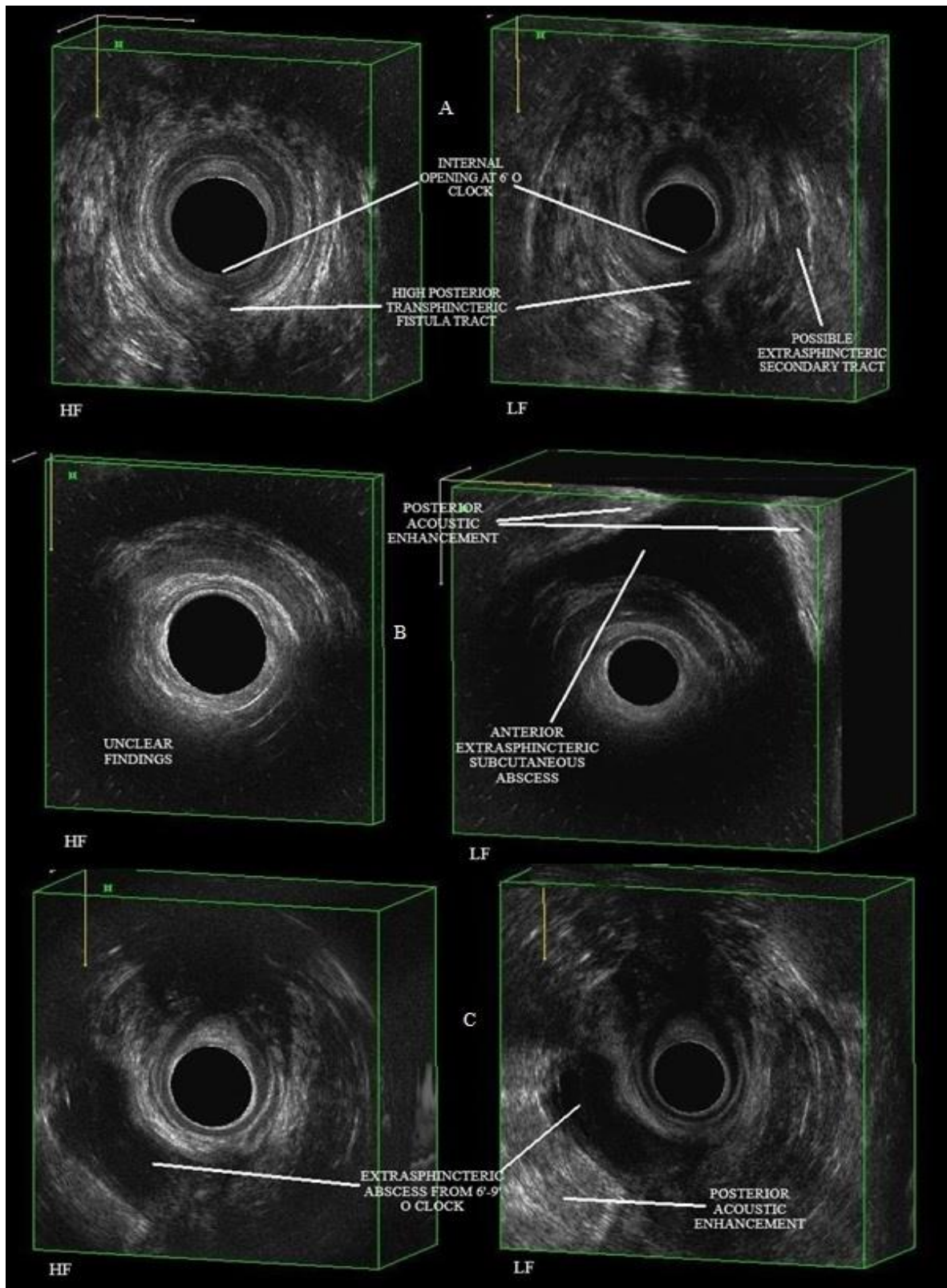


Figure 6 (A-C): A posterior high transphincteric fistula with a clear internal opening at 6 o'clock (Cho criteria III) similar to the previous image but a possible secondary tract from 6 to 2 o'clock is prominent in the LF image which is not clearly visible in the HF image. Image is a case of anterior subcutaneous extraspincteric abscess which is unclear in the HF image but is visible in the LF image with surrounding PAE. The abscess extends anteriorly beyond the LF field. As this patient had pain during the procedure and was not cooperative, a classical 3D cuboid image could not be obtained. Image shows an extraspincteric abscess from 6 to 9 o'clock seen in both HF and LF images but with prominent PAE in the LF image.

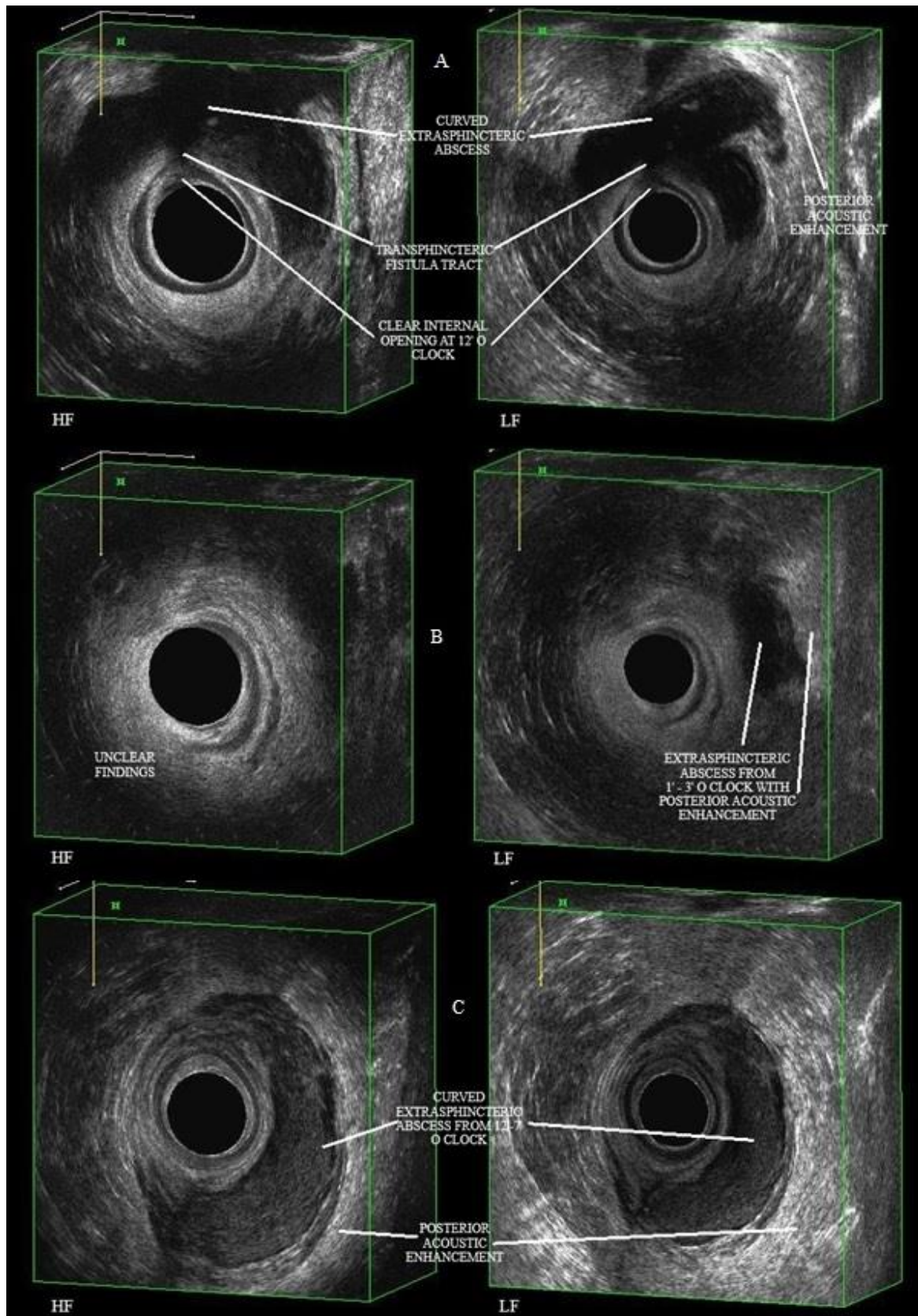


Figure 7 (A-C): An anterior horseshoe extrasphincteric abscess with anterior extension, opening internally at 12 o'clock (Cho criteria III) via a mid-transphincteric fistula tract. Anatomy is apparent in both HF and LF images but the anterior extension and PAE are more prominent in the LF image. Image shows an extrasphincteric abscess from 2 to 4 o'clock which is not seen in HF image but is seen in LF image with PAE. Image shows a hemi horseshoe abscess from 12 to 7 o'clock which is seen in both HF and LF images with prominent PAE in LF image.

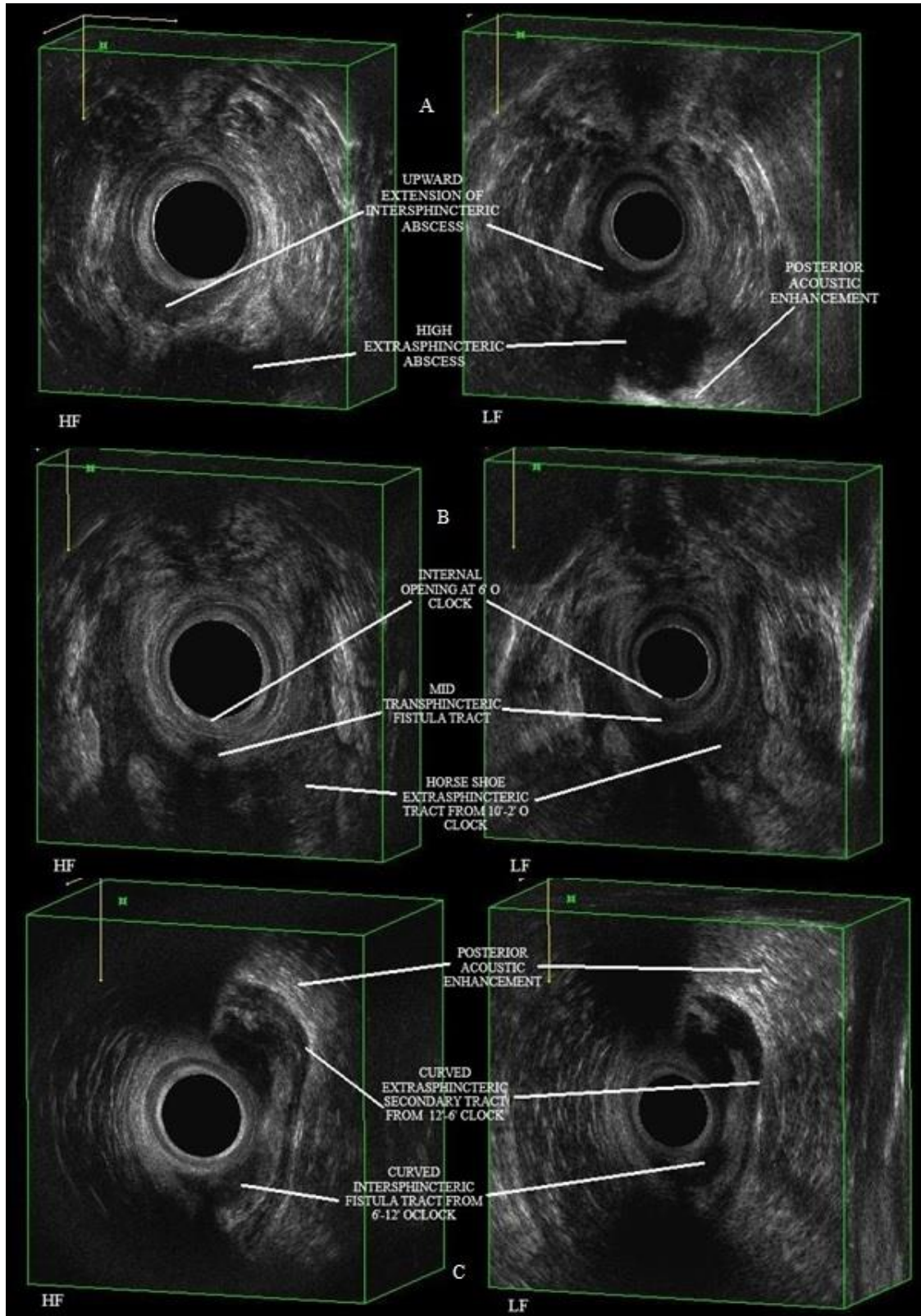


Figure 8 (A-C): An upward extension of the intersphincteric abscess visible in both HF and LF images with a posterior extrasphincteric abscess from 5' to 7' o'clock with PAE which is more obvious in the LF image that can be missed in the HF image. A posterior horseshoe fistula tract from 2' to 10' o'clock position opening internally at 6' o'clock (Cho criteria II) via a mid-transphincteric tract in the posterior midline. Both HF and LF images are clear. Complex fistula with a curved intersphincteric fistula tract from 6 to 12 o'clock communicating at 1 o'clock to an extrasphincteric secondary tract from 12 to 6 o'clock. PAE is seen from 12 to 2 o'clock more prominent in the LF image.

A comparison of the HF and LF images of various perianal fistula and abscesses are shown from Figures 4 B to 8 C.

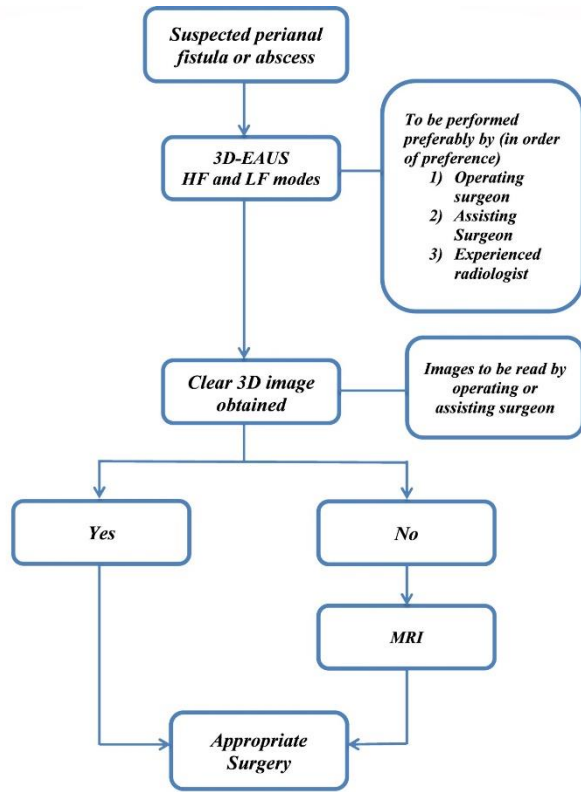


Figure 9: Diagnostic algorithm for management of perianal fistula and abscess.

On a scale of 0-2 for diagnosing perianal fistula and abscess with 0=poor image, 1=good image, and 2=excellent image, out of the above 12 images (Figures 4 B-8 C), HF images score 16/24 points whereas LF images score 22/24 points (Table 1). The score is according to the author’s subjective opinion. The readers can score according to their experience and perception of the images.

Table 1: Image quality scores of HF and LF images.

Figure no.	HF points	LF points
4B	2	1
5A	2	1
5B	2	2
6A	1	2
6B	0	2
6C	1	2
7A	1	2
7B	0	2
7C	2	2
8A	1	2
8B	2	2
8C	2	2
Total	16/24	22/24

DISCUSSION

Santoro et al have described the basic principles of endoanal ultrasound, the anatomy and the role of endoanal sonography in different perianal conditions published in 2006 when the frequency of earlier endoanal transducers was in the range of 5-10 MHz with most of the studies frequency was either 7 MHz or 10 MHz.¹⁷ With the newer transducers, the frequency ranges from 6-16 MHz.¹⁵ In our study, the frequency settings we used were 9 MHz for LF and 13MHz for HF by default. The HF setting in older transducers (10 MHz) is near to the LF settings in the newer transducers (9 MHz). As the maximum frequency range of the transducers has increased from 10 MHz to 16 MHz over time, the accuracy of diagnosing the perianal fistula and abscess in the inter-sphincteric and trans-phincteric planes and the internal opening has improved due to improved resolution.¹⁷ Previous studies that used a 7 MHz transducer had more accuracy in identifying the fistula tract and the studies that used a 10 MHz transducer had high accuracy in identifying the internal opening.^{18,19}

In HF mode the operating frequency is 10 MHz, 13 MHz, or 16 MHz and for LF mode it is 6 MHz, 9 MHz, or 12 MHz (manufacturer quoted).²⁰ Harkin et al in their study have concluded that as the depth of penetration increases the average intensity decreases. They proposed the appropriate start-up settings would be HF mode with a frequency of 16 MHz in contrast to the default 13 MHz HF mode.²⁰ Their recommendation was based on a phantom design and was not based on clinical subjects.

The comparative images in our study have clearly shown that HF images can better delineate internal opening, inter-sphincteric and trans-sphincteric fistula tracts, and abscesses close to the transducer whereas LF images can better delineate extra-sphincteric tracts and abscess and the posterior acoustic enhancement which are away from the transducer, it can also identify the internal opening, inter-sphincteric and trans-sphincteric fistula tracts and abscess equivocal to HF images. HF images are poor in detecting and determining the extent of extra-sphincteric abscess and tracts, whereas LF images are good in detecting inter-sphincteric and trans-sphincteric fistula tracts and internal openings and excellent in detecting and determining the extent of extra-sphincteric abscess and PAE (Table 1).

Volume render mode (VRM) is a good adjunct to 3D mode for detecting perianal fistula and abscess more accurately.¹⁵ Making use of the VRM along with the 6-up mode for both HF and LF images where required can improve the 3D anatomy accuracy of the perianal fistula and abscess.

We propose a diagnostic algorithm for imaging in perianal fistula and abscess. After clinical suspicion of fistula or abscess, the first line of investigation should be 3D-EAUS to be performed preferably by the operating or

assisting surgeon or an experienced radiologist who should clinically examine the fistula either before or after performing the 3D-EAUS scan. The scan should be performed in both HF and low-frequency modes with or without hydrogen peroxide instillation through the external opening. The 3D images should be read in both the HF and LF modes along with volume render and 6 up modes when required by the operating or assisting surgeon before surgery which improves the anatomical knowledge of the perianal fistula and abscess and helps in planning appropriate surgery and reduce the chance of fistula recurrence and fecal incontinence post-surgery. When the image is not satisfactory, an MRI should be advised (Figure 9). If the 3D image is clear even if it was a complex fistula or abscess an MRI is not routinely indicated. If the image is not clear or altered anatomy, severe perianal pain (ex-recurrent fistula, post-operative patient), or the disease is extending beyond the limits of the 3D-EAUS field then MRI is advised before surgery.

In contrast to the present algorithm that for simple fistula, 3D-EAUS is the investigation, and for all complex fistulas MRI may be indicated as an adjunct investigation by Brilliantino et al we propose that complex fistulas if completely delineated by a combination of high and low-frequency 3D-EAUS doesn't require an MRI if performed and reported by an experienced surgeon or a radiologist.⁶

Endoanal MRI is another modality where a coil is placed inside the anorectum followed by routine MRI scanning. Endoanal MRI for diagnosing fistula in ano has similar accuracy as 3D-EAUS.³ The disadvantage of 3D-EAUS is the limited availability of the machine only in a few centers in developing countries and the limited number of skilled surgeons and radiologists who can perform and read the scans. But MRI though costlier than 3D-EAUS in some places has better availability of the machine and experienced radiologists who can read and report the MRI scan. Films are available in MRI hence surgeons can read the images irrespective of the subjective radiologist's report and can plan relevant surgery. In 3D-EAUS the radiologist's report is the only major source of information though few centers provide USG images along with pictorial representation which cannot be completely relied upon.

Limitations

Our study was a retrospective study. The comparison of the HF and LF images were subjective perception of the authors.

CONCLUSION

3D-EAUS should be performed in both high and low-frequency modes preferably by the operating or assisting surgeons who are involved in surgery. Both frequency modes complement each other with the low-frequency mode having added advantage of a greater field of vision

and increased accuracy in detecting tracts or abscesses in the extra-sphincteric space. Low-frequency mode bridges the gap between HF 3D-EAUS and MRI in detecting complex perianal fistula and abscess. MRI is indicated when both frequency modes fail to conclude the complete anatomy of the perianal fistula or abscess. Routine use of high and low-frequency mode along with volume render or 6-up mode where required can better delineate the anatomy of the fistula and abscess. Surgeons should gain expertise in performing the 3D-EAUS and read the 3D images thus obtained. We recommend further studies correlating high and low-frequency 3D-EAUS to surgical or MRI findings.

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