3D Anorectal Ultrasound

Anorectal Endosonography
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3D Anorectal Ultrasound

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2D and 3D anorectal endosonography has proved its usefulness, and today medical specialists within such areas as pelvic floor imaging, coloproctology, colorectal surgery, incontinence, and uro-gynecology are well aware of its value.

Introduction

Although two-dimensional endosonography is very valuable, it has some shortcomings. Images are normally produced only in the transaxial scanning plane with the anterior of the patient at the 12 o’clock position. The only way to extend a scanning in the proximal-distal direction is to move the probe farther in or out of the anal canal or rectum. Precise positioning of the probe is crucial to the examination.

3D anorectal endosonography extends the usefulness of anal endosonography. The data from a series of closely-spaced two-dimensional images is combined to create a 3D image that can be freely rotated and sliced to allow the operator to get the most information out of the data – while not under the time pressure of the examination itself. In some situations, if it is difficult to pass the area occupied by a rectal tumor, only one acquisition of images may be possible. The data stored in a file originating from an acquisition can then be reviewed at any time.

After a data set is acquired, it is immediately possible to select coronal anterior-posterior (A-P) or posterior-anterior (P-A) as well as sagittal right-left (R-L) views (Fig 1). Coronal and oblique views are also available to the examiner.

Fig. 1. Closely spaced 2D images are combined to create a 3D image. The 3D image can be rotated and sliced for further inspection.
In contrast to a conventional 2D image or indeed a 3D image, new techniques such as Volume Render mode contains features for modifying the opacity of a 3D data set. This can be combined with filter and thickness features for truly new presentations of sphincter tears and for following fistulas-in-ano in all anatomical planes. These views offer an unsurpassed source of information to use in evaluating the patient. The results of the 3D anorectal scan can change the treatment of the patient. It is possible to see the invasion of a rectal tumor, the type of a fistula, and the extent of anal sphincter damage. This knowledge can be used to change the surgical management of the patient. The diagnosis is less dependent on one examiner, because the data can be reviewed by several specialists.

*a 3D image can be freely rotated and sliced, allowing the operator to get the most information out of the data.*

Previously the gold standard for imaging anal fistula cases was magnetic resonance (MR) using an endoanal coil. Using an MR machine for this application, however, is delicate and time-consuming. The introduction of very high frequency ultrasound transducers and 3D anorectal ultrasound, with the improved imaging possibilities that result, may change the standard to using ultrasound for imaging anal fistulas.

Several studies have been done on morphology of the anal canal seen on 2D and 3D endoanal ultrasound and correlation between endosonographic sphincter defects and anal incontinence. Today ultrasound is the gold standard when investigating fecal incontinence.

The value of endoanal ultrasound in anal cancer is more controversial. Some find it very useful for preoperative staging as well as follow-up after radiation treatment.

MR, using an endocoil in staging of rectal tumors, has not shown higher accuracy in early rectal cancer than 2D rectal ultrasound. To date, no comparative studies have been done on 3D endorectal ultrasound and MR in benign tumors or early rectal cancer.

Using 2D and 3D endorectal ultrasound it is possible to see the invasion of a rectal tumor, to distinguish between benign lesions and early rectal cancer, and it has shown to be useful in follow up of rectal cancer. When compared to 2D, 3D endorectal ultrasound is advantageous because the image can be saved and studied in different planes after the examination.
Equipment

Obtaining high-quality images of the anal canal and the rectal wall makes specific demands on the equipment used. The probe technology required for recording high quality images of the anal canal and the rectal wall is unique when compared to probes used for other endosonographic applications. An endoanal probe must permit a 360° image mode, and it must facilitate a high center frequency. The probe head diameter should be relatively small and cylindrical for maneuvering the transducer in the anal canal. The walls must be parallel over the length of the scanning.

In endorectal ultrasound, a water standoff system is applied to ensure acoustic contact between the sound-emitting crystal and the rectal wall.

A multifrequency transducer type is an advantage for imaging a process deep in the tissue. The 2052 probe (Fig. 2) offers a wide frequency range — from 6–16 MHz.

Fig. 2. BK Medical Ultrasound probe type 2052.
Anal Endosonography

 Acquisition of 3D anorectal images

The same type of transducer facilitates 2D and 3D imaging techniques.

A 3D reconstruction is based on a high number of parallel transaxial images acquired by means of a precision movement of the crystal assembly inside the BK Medical ultrasound probe type 2052.

The built-in high-resolution 3D acquisition system can be operated at different levels of definition. For the anorectal application, the usual setting is 0.25 mm between adjacent transaxial images. Scanning the anal canal or the rectum wall with these settings over an acquisition distance between 30 and 60 mm will typically yield from 120 to 240 parallel image slices (Fig.1).

Fig. 3. The normal 2-D anal sphincter complex.

Fig. 4. Female; high canal. Puborectalis seen.

Fig. 5. Female; coronal view. 3-D image of the normal anal canal.

Fig. 6. Female; mid canal. Approximately at the level of the dentate line.

Fig. 7. Female; 3-D image of normal EAS complex.
**Anal Endosonography**

Fig. 3 shows a 2D image of the anal canal. The external sphincter is seen forming a 360° intact circle. The image is recorded as a mid-canal image (slightly higher than the level of the dentate line). The perineal body is partially visible ventral to the anterior EAS, and the transverse perinei are imaged at 11 and 1 o’clock. Note the conjoining longitudinal muscle and the complete IAS.

The first ultrasound image recorded is normally at puborectalis level (high), where the perineal body is also seen in females. This image is normally documented and labeled HIGH (Fig. 4).

In a normal patient, moving the probe a few mm in the distal direction will show an intact anterior external anal sphincter (EAS) forming just below the superficial transverse perineal muscles. This image is a mid-canal projection where the internal anal sphincter (IAS) conjoining the longitudinal muscle (LM) and the superficial EAS all are identified. This image will be labeled MID (Fig. 6).

When the probe is pulled farther out, the image of the IAS will disappear, and only the subepithelium and the subcutaneous segment of the LM+EAS will be seen. This last image will be labeled LOW (Fig 8).

The labels in Fig. 5 indicate the High, Mid and Low positions on a 3D coronal A-P image.

In Fig. 7, note the perfect circular EAS anteriorly and left-lateral in this nulliparous female. The perineal body, together with the pubo-analis, is also very clearly seen.

In some women, you can see a descending pelvis (Figs. 10 and 11).

**Anal sphincter tears**

Anal sphincter tears can either be isolated to a defect in the EAS or the IAS alone or be a combination of an internal and an external sphincter defect. Scars can be either hypo- or hyperechoic.

![Fig. 8. Female; low canal. Only the subcutaneous EAS is seen.](image1)

![Fig. 9. Male; 3-D image of normal EAS complex.](image2)

![Fig. 10. 2D image does not show the IAS at the transverse perineal muscle level.](image3)

![Fig. 11. 3D image shows the IAS exists but is located more proximally (arrow).](image4)
Fig. 12 shows a transaxial image of an EAS tear, while Fig. 13 shows a 3D image of an anterior EAS tear using volume rendering techniques. The 2D image of a combined internal and external sphincter defect is seen in Fig. 14. 3D images of the same female illustrates the rubber band effect of a ruptured internal sphincter and the missing anterior part of the sphincters (Fig. 15).

**Anal fistulas and abscesses**

It is considered a delicate and problematic task to image anal fistula cases using only 2D transaxial ultrasound. The fistula tracts are almost impossible to follow, and it is even harder to identify any internal opening.

In these cases, 3D endoanal ultrasound offers a significant advantage over conventional 2D ultrasound. If an external opening can be identified, some doctors will introduce hydrogen peroxide H$_2$O$_2$ (3-5%) into the opening immediately before acquiring a 3D data set. Data acquisition will take approximately 30 sec. for a high-resolution scan. For this short period, the H$_2$O$_2$ enhances the fistula tracts so that they appear as bright white structures in the ultrasound image. Applying Volume Render Mode to a 3D data set will further enhance the image of the branches of a fistula with or without the presence of any enhancing medium.

Fig. 16 shows a 2D transaxial image of an extrasphincteric fistula (verified on the 3D...
data set shown in Fig. 17 that was recorded in connection with the acquisition of this image). A fragment of the fistula in the 2D image and the entire fistula in the 3D image are seen as bright white echoic structures because of the image-enhancing properties of H$_2$O$_2$. An example of a low anal fistula is seen in Figs. 18 and 19.

An anovaginal fistula is seen as a fistula tract with air on ultrasound. Fig. 20 shows a fistula tract at 12 o’clock in the proximal part of the anal canal with hyperechoic air.

Abscesses are easily visualized as in this case, where the abscess is seen as an echo-poor cavity (Fig. 21).

Anal cancer

Figs. 22 and 23 show an example of anal cancer before and after radiation therapy. The tumor is located from 2 to 8 o’clock and penetrates the external sphincter (T2b). After radiation treatment, the tumor has disappeared.
Rectal Endosonography

The rectal wall consists of 3 layers surrounded by perirectal fat (Fig. 24). Ultrasound studies of the rectum show 5 interfaces represented in the image as 3 hyperechoic and 2 hypoechoic structures (Fig. 25).

The interfaces represent 1) the hyperechoic interface between the water-filled balloon and the mucosa, 2) the hypoechoic deep mucosa (lamina propria and muscularis mucosae), 3) the hyperechoic submucosa, 4) the hypoechoic muscularis propria and 5) the hyperechoic interface between the rectal wall and the perirectal fat tissue.

Before deciding whether management of the patient should include preoperative radiation therapy for rectal cancer, it is important to know whether the tumor is confined to the rectal wall (T1 or T2 tumor) or penetrates into the perirectal fat (T3 tumor).

Studies have shown that endorectal ultrasound is superior to MRI in staging early rectal cancer. In advanced T3 or T4 tumors, MRI should be preferred because of the lower image depth of...
Fig. 25. The 5 layers of the rectal wall as seen on endorectal ultrasound.

high frequency endosonography and its difficulty in passing advanced rectal tumors. Endorectal ultrasound can also distinguish between benign lesions and early rectal cancer when decision for transanal endoscopic microsurgery (TEM) has to be taken, but staging of malignant rectal polyps in patients with previously excised polyps is difficult. The diagnostic accuracy of the assessment of lymph node involvement is not particularly good using endorectal ultrasound nor MRI. Enlarged (>5mm) lymph nodes can be seen on endorectal ultrasound, but it is difficult to assess the etiology of an enlargement with any degree of certainty.

3D offers a valuable supplement to conventional ultrasound. For example, it makes it possible to project the tumor in the entire proximal-distal anterior-posterior extension.
Rectal Endosonography

In Figs. 26 and 27, the images show a normal rectal wall. The 5 layers of the rectal wall are clearly illustrated in the coronal plane as well as in the axial plane. Figs. 28 and 29 are images of a benign T0 tumour. An enlargement of the mucosa, but no disruption of the 5 layers, is seen. Figs. 30 and 31 show a T1 tumour with disruption of the submucosa. A T2 tumour (Figs. 32 and 33) is often difficult to distinguish from a T1 tumour. As in a T1 tumour, the submucosa is disrupted, but the muscularis propria is not as clearly defined.

Figs. 34 and 35 show a T3 tumor. All the layers are disrupted and the tumor penetrates into the perirectal fat. Observe the typical fingerprints in the perirectal fat (arrow).
Conclusion

BK Medical’s 3D imaging possibilities add extra value to anorectal endosonography. Advantages for the patient are that an extensive set of data can be taken at one time. The physician can later study the patient’s data in a variety of ways, without the need for an additional ultrasound examination to acquire data from a different position or angle, and a non-examiner can study images recorded by colleagues.

For the physician, the advantages are clear. The 3D ultrasound equipment can be brought to the operating room, and ultrasound scanning can be performed per- and postoperatively by the surgeon. The diagnosis is less dependent on one examiner, because the data can be reviewed by several specialists. Data acquisition is simple and done without moving the probe inside the patient. Furthermore, there is less need for precise positioning of the probe to make sure you don’t miss something. All the data is captured, ready to be examined later, in as many ways as necessary.

With advantages for both the physician and the patient, 3D imaging extends the usefulness of anorectal endosonography.
References


With more than 30 years of commitment to ultrasound innovation, BK Medical specializes in the development, manufacture and distribution of dedicated ultrasound solutions. BK Medical has its headquarters in suburban Copenhagen, Denmark, and has offices and distributors throughout the world.

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