The management of complex anorectal fistulas is associated with potential risk of fecal incontinence and recurrences. Understanding type and height of the fistulous tract has clinical relevance for colorectal surgeons in order to select the optimal surgical approach. History and physical examination along with selective imaging to delineate the anatomy of the fistula are critical to individualize the patient’s treatment. Three-dimensional endoanal ultrasound provides an accurate and reproducible assessment of perianal sepsis and in many cases, the result is not different from that of MRI. Due to higher panoramicity, multiplanar reconstruction allows to visualize the fistula tracts in the context of the surrounding structures. Ultrasound has several important advantages: relative ease of use, minimal discomfort, cost-effectiveness, relatively non-time consuming, and wide availability in the clinical setting. This modality has a favourable impact on the outcome of surgical treatment for complex anal fistulas reducing the recurrence rate, minimizing postoperative complications and preserving anal continence.

Key words: Anal fistula, endoanal ultrasound, three-dimensional ultrasound

INTRODUCTION

According to the standards practice task force of the American Society of Colon and Rectal Surgeons (ASCRS) an anorectal fistula may be termed “complex” when one or more of the following findings are present: the tract crosses more than 30% of the external anal sphincter (EAS) (high transsphincteric with or without a high blind tract, suprasphincteric, and extraspincteric), horseshoe configuration, anterior location in a female, multiple tracts, recurrent, Crohn’s disease, prior radiotherapy, or baseline incontinence. The management of complex anorectal fistulas represents a surgical challenge because of the risk of potential damage to the anal sphincters and subsequent poor functional outcome. Post-operative fecal incontinence (FI) rates have been described as high as 35%2. Treatment requires, therefore, a detailed pre-operative diagnostic evaluation to determine the type and height of the fistula and the anatomy of the anal canal1.

Magnetic resonance imaging (MRI) and endo-anal ultrasound (EAUS) provide useful information to select the surgical approach and reduce the risk of sphincter damage. Advantages of MRI are the ability to identify high transspincteric, extra-spincteric and supraspincteric tracts, and differentiate recurrent fistula from postoperative scar3-8. Its use, however, is still limited by cost and access restrictions. EAUS provides an accurate assessment of perianal sepsis and in many cases, the result is not different from that of MRI6,9-10. Ultrasound has several important advantages: relative ease of use, minimal discomfort, cost-effectiveness, relatively non-time consuming, and wide availability in the clinical setting. The recent advent of three-dimensional (3D) US with post-processing modality (Volume Rendering) has further improved the accuracy of this technique11-12.

In this review, the technical aspects of 3D-EAUS and its influence on the management and outcome of patients with complex anorectal fistula are described.

3D-EAUS TECHNIQUE

Patients are commonly assessed in the left lateral position. No bowel preparation or enema are administered. Endoanal US may be performed with high multi-frequency (9-16 MHz), 360° rotational mechanical probe (type 2052, B-K Medical Analogic, Herlev, Denmark) or radial electronic probe (type AR 54 AW, frequency: 5-10 MHz, Hitachi Medical Systems, Japan)1. The difference between these two transducers is that the 3D acquisition
is free-hand with the electronic transducer, whereas the mechanical transducer has an internal automated motorized system that allows an acquisition of 300 aligned transaxial 2D images over a distance of 60 mm in 60 seconds, without any movement of the probe within the tissue. The set of 2D images is instantaneously reconstructed into a high resolution 3D image for real time manipulation and volume rendering. The 3D volume can also be archived for offline analysis on the ultrasonographic system or on PC with the help of dedicated software. It is possible to select coronal, anterior-posterior or posterior-anterior and sagittal right-left views, together with any oblique image plane. The 3D image can be rotated, tilted and sliced to allow the operator to infinitely vary the different section parameters, visualize the lesion at different angles and measure accurately, area, angle, and volume. Volume Render Mode (VRM) is a special feature that can be applied to high-resolution 3D data volume so information inside the cube is reconstructed to some extent. By use of a combination of 4 different postprocessing parameters (opacity, luminance, thickness and filter), the volume-rendered image provides better visualization performance when there are not large differences in the signal levels of pathologic structures compared with surrounding tissues.

**US ANATOMY OF THE NORMAL ANAL CANAL**

On US, five hypoechoic and hyperechoic layers can be seen in the normal anal canal:

1. the first hyperechoic layer, from inner to outer, corresponds to the interface of the transducer with the anal mucosal surface;
2. the second layer represents the subepithelial tissues and appears moderately reflective. The mucosa as well dentate line are not visualized. The muscularis submucosa ani can be sonographically identified in the upper part of the anal canal as a low reflective band;
3. the third hypoechoic layer corresponds to the internal anal sphincter (IAS). The sphincter is not completely symmetric, either in thickness or termination. It can be traced superiorly into the circular muscle of the rectum, extending from the anorectal junction to approximately 1 cm below the dentate line. In older age groups, the IAS loses its uniform low echogenicity, which is characteristic of smooth muscle throughout the gut, to become more echogenic and inhomogeneous in texture;
4. the fourth hyperechoic layer represents the longitudinal muscle (LM). It presents a wide variability in thickness and not always is distinctly visible along the entire anal canal. The LM appears moderately echogenic, which is surprising as it is mainly smooth muscle, however an increased fibrous stroma may account for this. In the intersphincteric space the LM conjoins with striated muscular fibers from the levator ani, particularly the puboanalis, and a large fibroelastic element derived from the endopelvic fascia to form the “conjoined longitudinal layer” (CLL). Its fibroelastic component, permeating through the subcutaneous part of the EAS, terminates in the perianal skin;
5. the fifth mixed echogenic layer corresponds to the EAS. The EAS is made up of voluntary muscle that encompasses the anal canal. It is described as having three parts: 1) the deep part is integral with the puborectalis (PR) muscle. Posteriorly there is some ligamentous attachment. Anteriorly some fibres are circular and some decussate into the deep transverse perinei; 2) the superficial part has a very broad attachment to the underside of
the coccyx via the anococcygeal ligament. Anteriorly there is a division into circular fibres and a decussation to the superficial transverse perinei; 3) the subcutaneous part lies below the IAS.

Ultrasound imaging of the anal canal be divided into three levels of assessment in the axial plane (upper, middle and lower levels) referring to the following anatomical structures:

1. UPPER LEVEL: the sling of the puborectalis (PR), the deep part of the EAS and the complete ring of IAS;

2. MIDDLE LEVEL: the superficial part of the EAS (complete ring), the CLL, the IAS (complete ring), the transverse perinei muscles;

3. LOWER LEVEL: the subcutaneous part of the EAS.

The anal canal length is the distance measured between the proximal canal, where the PR is identified, and the lower border of the subcutaneous EAS. Multiplanar EAUS has enabled detailed longitudinal measurement of the components of the anal canal. Williams et al. reported that the anterior EAS is significantly longer in men than women (30.1 mm vs. 16.9 mm; P<0.001). There is no difference in the length of the PR between men and women, indicating that the gender difference in anal canal length is solely due to the longer male EAS. The IAS did not differ in length between males and females. Regadas et al. demonstrated the asymmetrical shape of the anal canal and also confirmed that the anterior EAS is significantly shorter in female. West et al. reported similar results, with IAS and EAS volumes found larger in males than in females.

US ASSESSMENT OF ANORECTAL FISTULAS

The US examination is generally started using 10–13 MHz, changing to 7 or 5 MHz to optimize visualization of the deeper structures external to the anal sphincters. The PR muscle, and EAS, CLL, and IAS should always be identified and used as reference structures for the spatial orientation of the fistula or abscess. An anal abscess appears as a hypoechoic dyshomogeneous area, sometimes with hyperechoic spots within it, possibly in connection with a fistulous tract directed through the anal ca-
nal lumen. Abscesses are classified as superficial, intersphincteric, ischioanal, suprarelevator, pelvicrectal and horseshoe (Fig.1).

An anal fistula appears as a hypoechoic tract, which is followed along its crossing of the subepithelium, internal or external sphincters, and through the perianal spaces. With regard to the anal sphincters, according to Parks’ classification\(^\text{16}\), the fistulous primary tract can be classified into four types:

- **a. intersphincteric tract**, which is presented as a band of poor reflectivity within the longitudinal layer, causing widening and distortion of an otherwise narrow intersphincteric plane. The tract goes through the intersphincteric space without traversing the external sphincter fibers (Fig.2);

- **b. trans-sphincteric tract**, appearing as a poorly reflective tract running out through the external sphincter and disrupting its normal architecture. The point at which the main tract of the fistula traverses the sphincters defines the fistula level. Trans-sphincteric fistulae are divided into high, medium or low, corresponding to the ultrasound level of the anal canal \(^\text{17}\). Low trans-sphincteric tract traverses only the distal EAS third at the lower portion of the medium anal canal. Medium trans-sphincteric tract traverses both EAS and IAS, in the middle part of the medium anal canal. High trans-sphincteric tract traverses both sphincters in the higher part of the medium anal canal, in the space below the PR (Fig.3);

- **c. suprasphincteric tract**, which goes above or through the PR level. It can be very difficult to determine a suprasphincteric extension because EAUS is not able to visualize the precise position of the levator plate that lies in the same plane as the US beam;

- **d. extrasphincteric tract**, which may be seen close to but more laterally placed around the EAS.

Differentiation between granulated tracts and scars is sometimes difficult. Straight tracts are easily identified, but smaller and oblique tracts are more difficult to image. Secondary tracts, when present, are related to the main one and are classified as intersphincteric, trans-sphincteric, suprasphincteric, or extrasphincteric. Similarly, horseshoe tracts, when identified, are categorized as intersphincteric, suprasphincteric, or extrasphincteric. The exact location (radial site and anal canal level) of the internal opening can be difficult to define, as the dentate line cannot be identified as a discrete anatomical entity on EAUS. It is assumed to lie at approximately mid-anal canal level, which is midway between the superior border of the PR muscle and the most caudal extent of the subcutaneous EAS. According to this, the site of the internal opening is categorized as being above, at, or below the dentate line, or in the rectal ampulla. In addition, the site can also be characterized by the clock position, being classified from 1 o’clock to 12 o’clock. The internal opening can be identified as hypoechoic (when acute inflammation is present) or hyperechoic area (when chronically inflamed).

The majority of problems while investigating primary tracts with EAUS occur because of the structural alterations of the anal canal and perianal muscles and tissues, which can overstage the fistula, or poor definition of the tract when filled with inflammatory tissue, which can downstage the fistula. The disappointing results of EAUS in diagnosing the extrasphincteric fistulas could be due to the echogenicity of the tracts, especially those with a narrow lumen, which is practically identical to the fat tissue in the ischioanal fossa, and to the short focal length of the transducer, which prevents imaging of fistula that are
Three-dimensional endoanal ultrasound in complex anorectal fistulas.

Located at large distance from the anal canal. For this reason, performing EAUS after injecting 1.0–2.0 ml of 3% hydrogen peroxide (HPUS) through the external opening of the fistula appears to be particularly useful. 

This technique allows identification of tracts whose presence has not been definitively established, or distinction of an active fistulous tract from postsurgical or post-trauma scar tissue (Fig. 4). Gas is a strong ultrasound reflector, and after injection, fistula tracts become hyperechoic and the internal opening is identified as an echogenic breach at the submucosa. Because the injected hydrogen peroxide often results in bubbling into the anal canal, which then acts as a barrier to the US wave, injection should be performed in two phases: an initial injection of a small amount of hydrogen peroxide, and a further injection at a greater pressure. A disadvantage inherent to hydrogen peroxide injection is the very strong reflection that occurs at a gas/tissue interface, which blanks out any detail deep to this interface. The bubbles produced by hydrogen peroxide induce acoustic shadowing deep to the tract, so all information deep to the inner surface of the tract is lost.

3D imaging allows the operator to follow the pathway of the fistulous tract along all the desired planes (axial, coronal, sagittal, oblique) (Figs. 1-5). In addition, volume render mode can facilitate depiction of a tortuous fistula tract after hydrogen peroxide injection, due to the transparency and depth information.

**LITERATURE REVIEW**

Initial experiences with EAUS reported a good accuracy for the selective identification of fistula (91.7%) and abscess (75%) configurations. However, a significant number of the internal openings (33.3%) were not detected. Worse results in the identification of the internal opening were reported by Poen et al. (5.3% accuracy), and Deen et al. (11% accuracy). Use of hydrogen peroxide increased the accuracy to 71% to 95% for primary tracts and to 63% to 96.1% for secondary tracts, while the accuracy of standard 2D-EAUS ranges from 50% to 91.7% for the primary tract and from 60% to 68% for secondary tracts. The highest concordance is usually reported for primary trans-sphincteric fistulae, while the major diagnostic difficulty is still the adequate identification of primary supra- and extrasphincteric fistulae. Injection can also contribute to a more accurate identification of the internal opening (HPUS accuracy ranging from 48% to 96.6% vs. EAUS accuracy ranging from 5.3% to 93.5%). Buchanan et al. reported a good accuracy of 3D-EAUS in detecting primary tracts (81%), secondary tracts (68%), and internal openings (90%) in 19 patients with recurrent or complex fistulae. The addition of hydrogen peroxide (3D-HPUS) did not improve these features (accuracies of 71%, 63% and 86%, respectively). Using 3D imaging, Ratto et al. reported an accuracy of 98.5% for primary tracts, 98.5% for secondary tracts, and 96.4% for internal openings, compared with 89.4%, 83.3%, and 87.9%, respectively, when the 2D system was used. Our experience on 57 patients with peri-anal fistulae confirmed that 3D reconstructions improved the accuracy of EAUS in the identification of internal opening compared to 2D-EAUS (89.5% vs. 66.7%; P=0.0033). Primary tracts, secondary tracts, and abscesses were similarly evaluated by both procedures. Ding et al. reported that preoperative use of 3D-EAUS has a favourable impact on the outcome of surgical treatment for anal fistulae, especially in complex anal fistulae, reducing the recurrence rate and the development of FI. They recommended that 3D-EAUS should be routinely used in the clinical setting. Garees-Albir et al. showed a higher accuracy of 3D-EAUS compared to 2D-EAUS for assessing height of primary tract. Both ultrasound techniques were adequate for the diagnosis of low transsphincteric fistulae, however 3D-EAUS was superior for the diagnosis of high transsphincteric tract. The same Authors showed a concordance rate between intraoperative findings and 3D- EAUS of 79% for primary fistula tracts, validating this technique in the evaluation of perianal fistulae. They demonstrated a tendency to overestimate fistula height with 2D-EAUS as shown by the lower specificity for the diagnosis of high transsphincteric tracts and lower sensitivity for low transsphincteric fistulae. Kim and Park found 84.4% accuracy of 3D-EAUS in detecting the primary tract. Brilliantino et al. demonstrated good agreement (κ=0.93) between 3D- EAUS and surgical assessment in the classification of primary fistula tracts. The overall sensitivity and specificity of 3D-EAUS in the diagnosis of perianal sepsis were 98.3% and 91.3%, respectively. These authors stated that this modality is reliable in the assessment of anal fistulae and may assist the surgeon in delineating the fistula tract anatomy, supporting the pre-
operative planning of appropriate surgical therapy. Another advantage of 3D-EAUS, is the possibility to define the length of IAS/EAS involvement in order to quantify how much sphincter can be safely divided during fistulotomy.

A variety of investigators have directly compared EAUS (2D/3D both with and without hydrogen peroxide injection through the external opening) with MRI (external phased array/endo-anal coil), and these comparisons have found EAUS variously superior\(^1\), equivalent \(^{10,15,22,24,32}\) or inferior.\(^3\) The difficulty in comparing these modalities is related to the ability to define a true reference standard for fistula-in-ano due to the following potential sources of bias: the operators who perform the assessments can have differing levels of experience with EAUS or with MRI and similarly, the surgeons who perform the operations have different levels of experience. For this reason, Buchanan and colleagues proposed the “outcome-derived” reference standard.\(^2\) If there is disagreement between findings at EAUS, MRI, and surgical examination, the findings associated with fistula healing should be assumed to be correct. Sahni and colleagues assessed the optimal technique for fistula classification using an “evidence based medicine” method.\(^4\) MRI was found to be more sensitive (0.97) than clinical examination (0.75) but comparable to EAUS (0.92) for discriminating between complex and simple fistula. EAUS has some clear advantages related to the fact that it is relatively cheap and simple to perform, it is rapid and well tolerated by patients and, unlike MRI, can be performed easily in the outpatient clinic or even on the ward since the machines are easily portable. It is vastly superior to digital examination and is therefore well worth performing. The major advantage of MRI over EAUS is the facility with which it can image extensions that would otherwise be missed since they can travel several centimeters from the primary tract. It is especially important to search for supraventricular extensions, since these are not only difficult to detect but pose specific difficulties with treatment. Complex extensions are especially common in patients with recurrent fistulae or with Crohn’s disease. MRI and EAUS provide complementary and additive information, and there are no disadvantages to performing both procedures in the same patient where local circumstances, availability, and economics allow this.

In conclusion, 3D-EAUS is an accurate and reproducible modality for the evaluation of type and height of anal fistulae, essential for planning surgical approach and to reduce the risk of recurrence and FI. It also provides excellent imaging of the secondary tracts, of the internal opening and of the involvement of the anal sphincters. In daily clinical practice, EAUS represents a simple office procedure, allowing real-time visualization and post-processing analysis. It has the potential to become the first-line investigation in patients with anal fistulae, which may alleviate the need for MRI in most patients.

**SUMMARY**

Lećenje kompleksnih perianalnih fistula je praveden značajnim rizikom od fekalne inkontinencije i recidiva. Preoperativno poznavanje tipa i putanje fistuloznog trakta je od izuzetnog značaja kako bi se planirala adekvatna hirurška intervencija. Istorija bolesti i fizikalni nalaz uz selektivnu primenu dijagnostičkih procedura mogu pojasniti anatomiju fistule i omogući izbor najbolje hirurške metode. Trodimenzionalni endoanalni ultrazvuk omogućuje dobijanje preciznih podataka kod pacijenata sa perianalnim abscesima i perianalnim fistulama pri čemu se rezultati u većini slučajeva ne razlikuju od rezultata dobijenih Magnetnom Rezonancijom. Multiplanarna rekonstrukcija omogućava jasniju vizualizaciju fistuloznog trakta i okolnih struktura. Endoanalni ultrazvuk ima nekoliko važnih prednosti: relativno lako i brzo se radi, pregled nije bolan već samo neprijatan za pacijenta, nije skup i lako je dostupan. Endoanalni ultrazvuk ima značajan uticaj na rezultate lećenja kompleksnih perianalnih fistula jer smanjuje procenat recidiva i postoperativnih komplikacija uključujući i fekalnu inkontinenciju.

**Ključne reči:** Analna fistula, endoanalni ultrazvuk, trodimenzionalni endoanalni ultrazvuk

**REFERENCES**


