Expert Reviews

Endoanal ultrasound in benign anorectal disorders: clinical relevance and possibilities

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Endoanal ultrasound is a well-established technique used to evaluate benign anorectal disorders. The technique is easy to perform, has a short learning curve and causes very little discomfort. Reconstruction of 3D images is possible. The clinical indications for endoanal ultrasound in benign anorectal diseases are fecal incontinence and peri-anal fistula. Sphincter defects can be depicted with precision and correlate perfectly with surgical findings. Furthermore, an impression of sphincter atrophy can be established. With perianal fistula the tracts can be visualized. Introducing hydrogen peroxide via the external fistula opening improves imaging. Endoanal ultrasound and MRI have comparable results in diagnosing anorectal disorders.

Keywords: anal endosonograpy • anal ultrasound • fecal incontinence • peri-anal fistula

Endoanal ultrasound (EUS) was introduced 25 years ago by urologists to evaluate the prostate [1]. Later, EUS was extended to other specialties to stage rectal tumors [2] and to investigate benign disorders of the anal sphincters and pelvic floor [3,4]. EUS has been used for almost every possible disorder in the anal region, and by delineating the anatomy it has increased insight into anal pathology.

Clinical indications for EUS in benign anorectal disease are fecal incontinence for the detection of defects and atrophy, perianal fistulas and abscesses to demonstrate the fistula tract(s).

Endoanal ultrasound is easy to perform, has a short learning curve and causes no more discomfort than a routine digital examination. A rotating probe with a 360° radius and a frequency between 5 and 16 MHz is introduced into the rectum. The probe is then slowly withdrawn manually or with a (internal) puller, so that the pelvic floor and subsequently the sphincter complex are seen. With special software, it is also possible to reconstruct 3D images.

Normal anorectal imaging

Endoanal imaging

Endoanal ultrasound apparatus & probes

The technique used in this imaging mode is that of the general form of mechanical energy emitted above the frequency of the human audibility (20,000 Hz). The operating frequency lies between 2.5 and 16 MHz. The image is formed by reflection at the interfaces of two structures. Part of the signal is transmitted and part is reflected. Reflections from deeper structures are weaker due to greater signal attenuation. This can be partly corrected by changing the frequency: lower frequencies (2.5 MHz) penetrate better into deeper layers, and superficial structures are better visualized with higher frequencies (16 MHz). Reverberation is an artifact due to a gross mismatch of acoustic impedance at an interface, usually an air–tissue interface. The signal echoes back and forth, giving rise to a series of concentric black and white rings. This is typically a problem in the rectum and in an asymmetrical anus when there is loss of contact with the anal canal. Several types of ultrasound probes have been developed. The first were single-transducer mechanical sector probes with a limited angle (120–210°) to investigate and puncture the prostate, but unsuitable for the sphincter. Later, radial probes were developed with a 360° view, and linear and curved array probes with a limited field were also developed. Ultrasound transducers at the tip of an endoscope can be used to evaluate the bowel wall. The advantage is both an endoscopic and ultrasound image, thus allowing investigation of small abnormalities in the

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bowel wall. The rubber balloon filled with water is not suitable for the anal canal as it is compressed and twisted into the rotating probe. A hard, water-filled cone is necessary to image the anal canal.

Several industries provide ultrasound apparatus. Rigid rotating endoprobes with a 360° view are preferable. Rigid mechanical probes are provided by B-K Medical (Herlev, Denmark) with a focal range of 5–16 MHz with 360° view, and by Aloka (7.5–12.5 MHz, 270°, Tokyo, Japan). The flexible endoscopic Olympus (Tokyo, Japan) radial scanner (7.5–12 MHz) has a 360° view. Flexible endoscopic sector scanners are by Pentax/Hitachi (sector scanner 100°, 5 and 7.5 MHz, Tokyo, Japan) and Olympus (180°, 7.5 MHz). B-K medical has also developed software to construct a 3D image. This can be used in conjunction with an automatic external or the more sophisticated internal puller in the B-K probe.

Performance

Generally, the patient is in the left lateral position. A digital rectal examination is mandatory to determine the presence of possible abnormalities (stenosis, painful lesion or tumor). The rigid probes are covered for hygienic reasons with a condom filled with ultrasound gel. Then the condom is covered with a gel on the outside and gently introduced into the rectum, following the anorectal angle. Landmarks are the prostate, vagina and puborectalis (PR) muscle. Then the probe is slowly withdrawn and enters the anal canal, where the anatomy, as described previously, can be seen. Pressure of the probe and gravity can lead to different thickness measurements (lying on the left side: left thickness measurements may be smaller).

EUS 2D versus 3D imaging

With 3D reconstruction, it is not only possible to view the transversal image but also the longitudinal and sagittal images. Subsequently, it is possible to measure the length and volume of the anal sphincters. Men have a longer anterior external anal sphincter (EAS) than women [5,6]. Multiplanar imaging has revealed a direct relationship between the length of a sphincter tear and its radial extent as shown on axial scanning [5]. The PR muscle is longer in men [6]. Volume measurement has been very disappointing; reproducibility of volume measurement is moderate [7,8]. No difference was found in the volume of the EAS of women with fecal incontinence and healthy women [7,8], and thus it is not a tool to be used to demonstrate sphincter atrophy [9]. Sphincter length and aspect are far more promising markers to show EAS atrophy [10]. Demonstration of sphincter defects may be improved by 3D-EUS [11]. The most impressive feature of 3D-EUS is the ease of viewing the anal sphincter from all different angles, thereby obtaining a better view and insight into the local pathology. Particularly in women, this research is ongoing [12,13]. Rendering of the 3D view may also improve the view [14].

Normal anatomy & morphology with EUS

The normal rectum is 11–15 cm long and has a maximum diameter of 4 cm. It is generally not empty but filled with some remainder of fecal material and/or air. This can interfere with obtaining an optimal acoustical surrounding for anal ultrasound. Adding water may improve the image. On EUS, the normal rectal wall is 2–3 mm thick and is composed of a five-layer structure (Figure 1), as is the rest of the digestive tract. The anal canal is 2–4 cm long and is closed in the normal situation. Therefore, excellent images can be obtained with EUS, as the anus lies tight around the probe. The (inner) circular smooth muscle layer of the rectum continues into the anus where it thickens and becomes the internal anal sphincter (IAS). The (outer) longitudinal component fuses with the EAS along the anal canal. The EAS is a voluntary muscle arising from the levator ani and PR muscle to form a circular structure around the anal canal. The anatomy of the EAS remains controversial and is usually described as having three parts: a deep part joining with the PR muscle, a superficial part attached to the superficial transverse perinei muscle, and a subcutaneous part continuing below the IAS. In addition, a longitudinal muscle being part of the innermost part of the external sphincter has been described. This anatomical description cannot always be found with EUS [15–17]. The perineal body is a so-called structure, a junctional zone where fibers from the IAS and EAS converge and fuse with muscles from the anterior urogenital area. Other parts of the pelvic floor are the anococcygeal ligament (posterior) and the levator ani, which consists of three parts: the PR muscle, the ileococcygeal muscle and the pubococcygeal muscle.

Endosonographic findings in healthy volunteers have been thoroughly investigated [15,16,18–34] and compared with anatomical preparations [16–18,21,24]. The PR muscle is almost always easily visualized and can serve as a point of orientation: it appears as a V-shaped echogenic band, which slings dorsally around the rectum (Figure 2). When

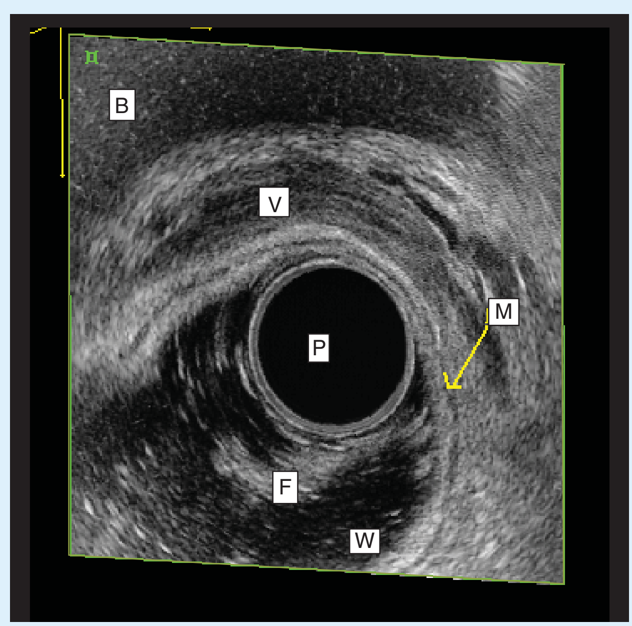

Figure 1. Normal rectum filled with water and fecal material. The muscularis of the rectum is clearly seen.
B: Bladder; F: Fecal material; M: Muscularis; P: Endoanal ultrasound probe; V: Vagina; W: Water.

withdrawing the probe, the echogenic band closes anteriorly, thus forming the EAS (Figure 3A). Figures 3B & C represent the lateral and coronal view, respectively. Thickness of the EAS is approximately 4–10 mm [20,22,25–28]. EAS is thinner and shorter anteriorly in women [19,25,27], which makes it more vulnerable to obstetric damage. EAS thickness is also correlated with bodyweight [12]. There is no clear relationship between EAS thickness and age [27–29]. Inside the EAS lies the IAS, which presents as a thin, echogenic lucent band of approximately 1–3 mm [20,22,23,25–31]. The IAS increases in thickness and echogenicity with age, both in patients [30,32] and healthy volunteers [23,24,27,29,31]. These findings are suggestive of sclerosis of the IAS in the elderly, which has been demonstrated histologically [33]; although this finding is not supported by another study [23]. The submucosal layer has a mixed echogenic aspect and is partly collapsed by pressure of the endoprobe [6]. Submucosal thickness increases slightly with age [27], probably due to internal hemorrhoids [34], and might be caused by physiological distal displacement or enlargement of the anal cushions [35]. The mucosa cannot be identified separately with the frequencies used. Other pelvic floor structures around the sphincter complex can also be visualized. There are some reports on visualizing the longitudinal muscle of the EAS, but the importance of this is controversial [15,16,19,22,24]. The anococcygeal ligament appears as an echo-poor triangle and causes tapering of the EAS or PR muscle [19,27]. Furthermore, the transverse perineal muscles, the ischiocavernous muscles, the urethra and pubic bones may be visualized [21,25,27].

Vaginal endosonography, to visualize the perianal area and especially the perineum, is an alternative when rectal endosonography is not possible when the anus is asymmetrical causing air artifacts, extreme anal stenosis or pain (Figure 4) [36]. Transperineal ultrasound is also used to image the perianal area in patients with perianal fistula [37,38] or imperforate anus [39]. However, results with EUS seem somewhat better [38,40].

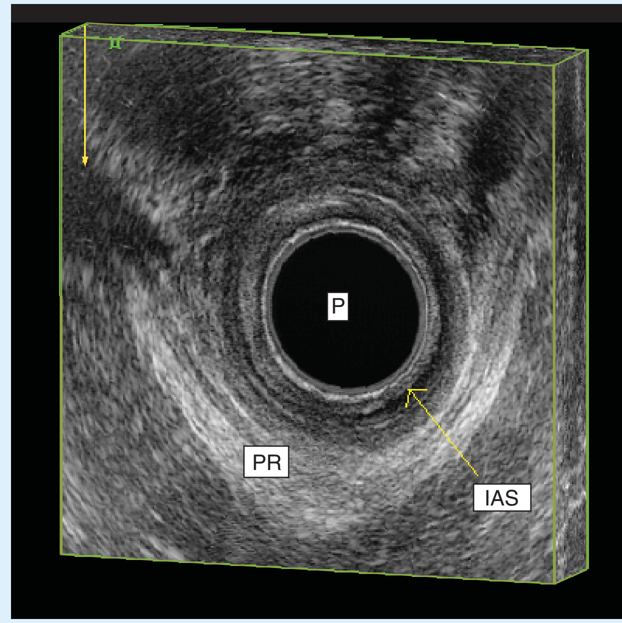

Figure 2. Normal image of the puborectal muscle.
IAS: Internal anal sphincter; P: Endoanal ultrasound probe; PR: Puborectal muscle.

Benign anorectal disease

Fecal incontinence

The importance of anal ultrasound in patients with fecal incontinence is detection of a sphincter defect. A significant sphincter defect (≥25% of the circumference) is generally considered to form an indication to perform sphincter repair in absence of very serious external sphincter atrophy. Demonstration of external anal sphincter atrophy is also possible.

Before the introduction of EUS, it was believed that pudendal nerve damage was the most common cause of obstetric fecal incontinence [41,42]. EUS has shown that obstetric sphincter trauma is the most common cause of fecal incontinence [43–48]. Other causes of sphincter damage are previous anorectal surgery, such as hemorrhoidectomy, lateral sphincterotomy, fistulotomy and transanal stapling of coloanal or ileoanal anastomoses [49–53].

Endoanal ultrasound may have a role in the prevention of anal incontinence, since EUS immediately performed after vaginal delivery allows diagnosis of undetected anal defects that might be associated with subsequent fecal incontinence [54]. Elective cesarean section can be recommended for women at increased risk of anal incontinence [55].

Accuracy of demonstrating anorectal sphincter injury with anal ultrasound

Endoanal ultrasound remains the gold standard in delineating the anatomy of the PR muscle and anal sphincter complex [20,23,56–58]. EUS can visualize defects, scarring, thinning and thickening, difference in echogenicity and other local alterations. The defects should be described, indicating their location (IAS, EAS or PR muscle), their size longitudinally (total, proximal or distal), and their circumference (°). Some semantic problems exist concerning the words defect, tear, scar and fibrosis. Clear disruption of the IAS or EAS are described as defects. Tears are defined by interruption of the fibrillar echo texture; scaring is defined more by loss of normal architecture, with usually low reflectiveness [59]. EUS demonstrates sphincter defects with high accuracy; sensitivity and specificity reach almost 100%. The described defects are confirmed during surgery [5,60–65].

Reproducibility for sphincter defects and anal sphincter thickness is good [5,66–69]. For the IAS, the agreement is higher than for the EAS. Due to its accuracy and simplicity, endosonography has replaced electromyographical sphincter mapping, since EUS is more reliable [63,65,70,71], provides information regarding the IAS, and is noninvasive, not painful and not time-consuming [65].

Sphincter defect size correlates with fecal incontinence severity and postoperative sphincter repair failure correlates with the remaining size of the sphincter defect [72]. Concomitant neuropathy may trouble that relationship [73,74]. However, finding a sphincter defect does not necessarily mean that it is the cause of fecal incontinence, as many people have sphincter defects without fecal incontinence [44]. On the other hand, patients with fecal incontinence can have intact sphincters, and pudendal or

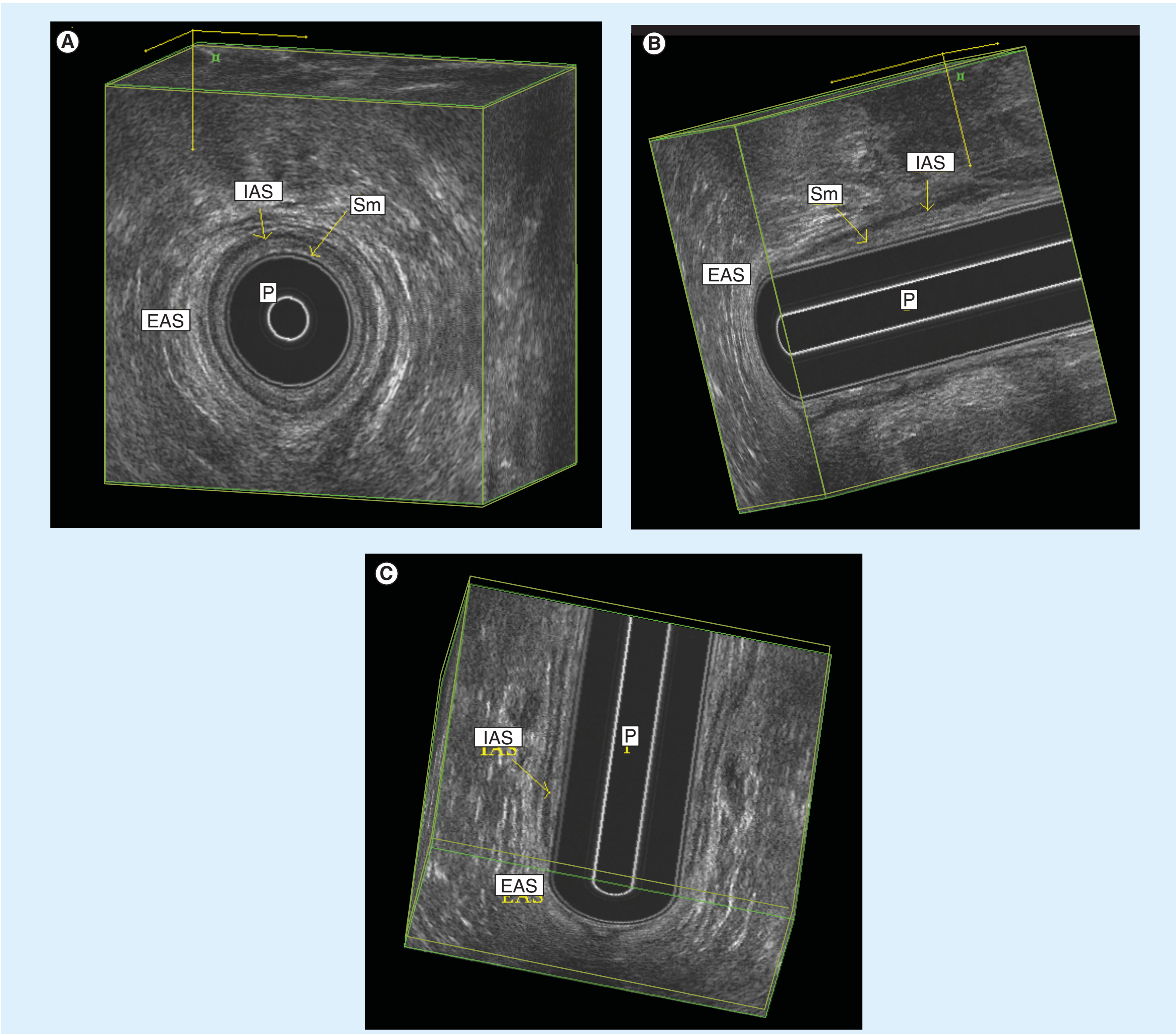

Figure 3. Normal endoanal ultrasound image of the anal sphincter. (A) Transversal view **(B)** Lateral view and **(C)** Coronal view. EAS: External anal sphincter; IAS: Internal anal sphincter; P: Endoanal ultrasound probe; Sm: Submucosa.

autonomic neuropathy leading to sphincter atrophy is then the cause [42,53]. When there is no sphincter defect, pudendal neuropathy is the cause of the fecal incontinence, provided that there is no diarrhea or a small rectal capacity [75].

The difficulty comes when there is a small sphincter defect with moderate anal sphincter pressures. Generally, a defect smaller than 25% of the circumference is not considered significant for anal sphincter repair. Another problem is very low sphincter pressures, signs of atrophy and a defect of 25%: the very low pressures and signs of atrophy suggest concomitant serious neuropathy, which interferes with successful surgery. Pudendal nerve terminal motor latency (PNTML) measurements are not conclusive [76], and decisions cannot be made on these measurements.

Internal anal sphincter abnormalities

The majority of lesions of the IAS are due to iatrogenic and obstetric injuries, often in combination with injuries to the EAS, leading to fecal incontinence. Smaller lesions leading to minor fecal incontinence or soiling are due to hemorrhoidectomy or mucosal prolapsectomy. Manual anal dilatation [77] or lateral internal sphincterotomy [78–80] are notorious and have been associated with fecal incontinence in 27 and 50% of patients, respectively. Fistula surgery can cause fecal incontinence in up to 60% of cases [81].

In a study of 50 patients after hemorrhoidectomy (n = 24), fistulectomy (n = 18) and internal sphincterotomy (n = 8), 23 (46%) had a defect of the anal sphincter (13 IAS, one EAS and nine combined defect): three after hemorrhoidectomy, 13 after fistulectomy

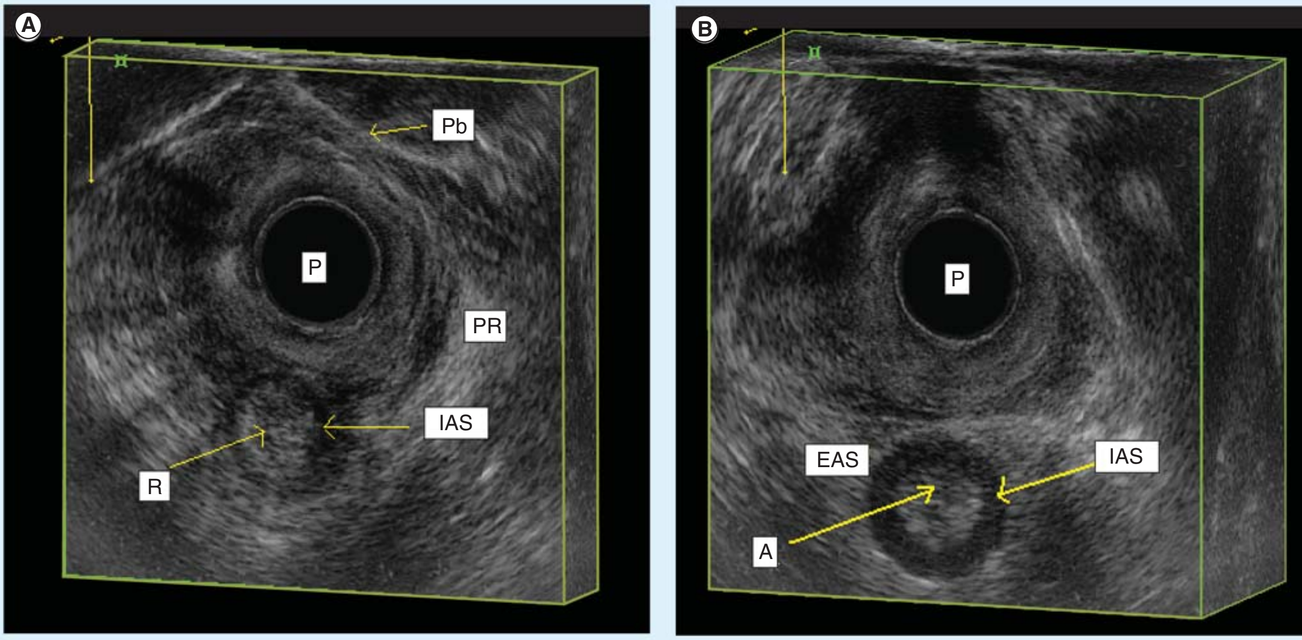

Figure 4. Vaginal image with probe in the vagina. (A) Level of the PR: the rectum is now collapsed and the submucosal hemorroidal plexes is seen as a hypechogenic area (arrow). The PR can be seen as a sling behind the rectum meeting the Pb. **(B)** Level of the sphincters: the external anal sphincter becomes visible as a circular ring.
A: Anal canal with collapsed mucosa and hemorroidal plexus (arrow); EAS: External anal sphincter; IAS: Internal anal sphincter; P: Probe; Pb: Puborectal bone; PR Puborectal muscle; R: Rectum.

and seven after internal sphincterotomy. Seven patients (30%) had symptoms, all had a sphincter defect. In the other 16 (70%), the sphincter defect did not produce symptoms [49].

Defects of the IAS are easily recognized owing to the prominent appearance of the IAS in the anal canal, as the defects appear as hyperechoic breaks in the hypoechogenic ring. The pattern of disruption is related to the type of surgery or trauma [82]. Manual dilatation will lead to several disruptions or sometimes to a diffuse thinning of the IAS. Patients after a lateral internal sphincterotomy will have a single lateral defect associated with a thickening of the remaining IAS due to retraction of the remaining muscle (Figure 5) [77,79]. After hemorrhoidectomy, defects can be seen where the hemorrhoids were removed. Fistula surgery leads to combined defects of IAS and EAS in the fistula tract. Reports have appeared regarding rare causes of fecal incontinence, such as primary IAS degeneration in passive fecal incontinence [53], sclerosis of the IAS in mixed connective tissue disease [83] and systemic sclerosis [84] with diffuse thinning (<0.2 mm) of the IAS.

External anal sphincter abnormalities

The typical appearance of this EAS defect is an anterior break in the circumferential integrity of the hyperechogenic band to a more hypoechogenic aspect (**Figures 6 & 7**). This corresponds to replacement of the normal striated muscle with granulation tissue and fibrosis. This should be well differentiated from a short EAS or the transition zone from puborectal muscle and EUS. With vaginal EUS, the relationship with the vagina becomes even more clear (**Figure 7B**). Particularly in women, an anterior sphincter defect (irregular mixed echogenic to hypoechogenic) must be well differentiated from the natural gap between the PR muscle in the upper anal canal (hypoechogenic; smooth, regular edges). Surgical defects will be at the location of the surgery.

There is wide variation in the incidence of clinically occult anal sphincter injuries diagnosed by EUS after the first vaginal delivery [43,47,85–91]. For primipara, the risk of developing a sphincter tear is 25%, and for subsequent deliveries it is 4% [43,92]. Fecal incontinence develops in 25% of such deliveries [93].

Instrumental delivery (forceps more than vacuum extraction), second stage of labor and high birth weight are associated with increased risk of anal sphincter injury [85,92,93]. In patients with perianal fistula with external fistula openings, the fistula tract can be differentiated from a defect by becoming hyperechogenic following introduction of hydrogen peroxide (hydrogen peroxide enhanced ultrasound [HPUS]) [94].

Puborectalis muscle abnormalities

As with the EAS, the PR muscle is a striated muscle and can also acquire defects or become atrophic. Defects of the PR muscle are rare and are related to dramatic anorectal trauma, such as from speedboat or traffic accidents. Sometimes with a high anorectal fistula, a defect of the puborectal PR muscle can be seen (**Figure 8**). A greater shortening of the PR muscle during contraction has been observed in patients with fecal incontinence [95].

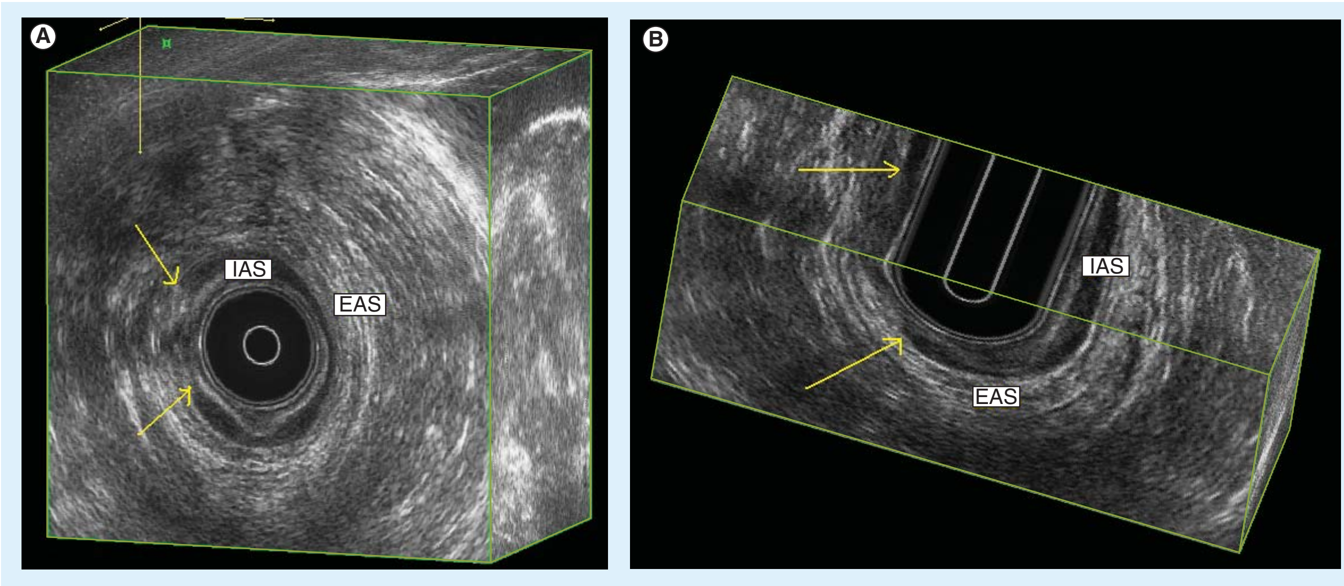

Figure 5. Defect (between arrows) of the IAS after a lateral internal sphincterotomy. (A) Tranverse view. **(B)** Lateral view.
EAS: External anal sphincter; IAS: Internal anal sphincter.

Sphincter atrophy

The term 'sphincter atrophy' refers mostly to external EAS atrophy, as the EAS is the most important factor for maintaining fecal continence. EAS atrophy is due to pudendal neuropathy caused by stretch injury during childbirth [96] or chronic constipation [97,98]. The importance of differentiating between the contribution of a defect or neuropathy/atrophy to the fecal incontinence lies in the fact that only patients with a significant sphincter defect are offered a sphincter repair.

It has been suggested that patients with low anal pressures and poor innervation to the pelvic floor and elderly patients have less favorable results with postanal repair [99,100] and anal

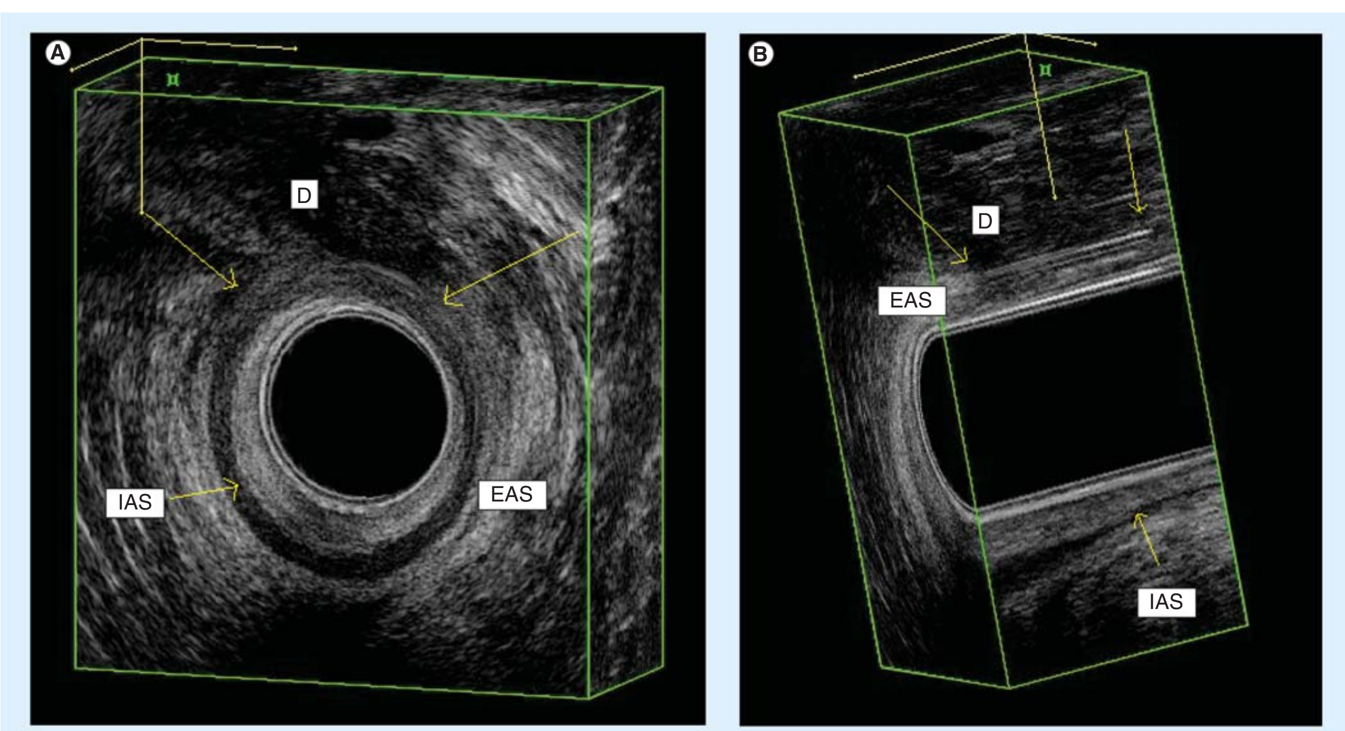

Figure 6. Large defect (arows) anterior in the external anal sphincter after childbirth. The underlying IAS is anteriorly not clearly demarkated and probably also damaged. **(A)** Transversal view. **(B)** Lateral view.
D: Defect; EAS: External anal sphincter; IAS: Internal anal sphincter.

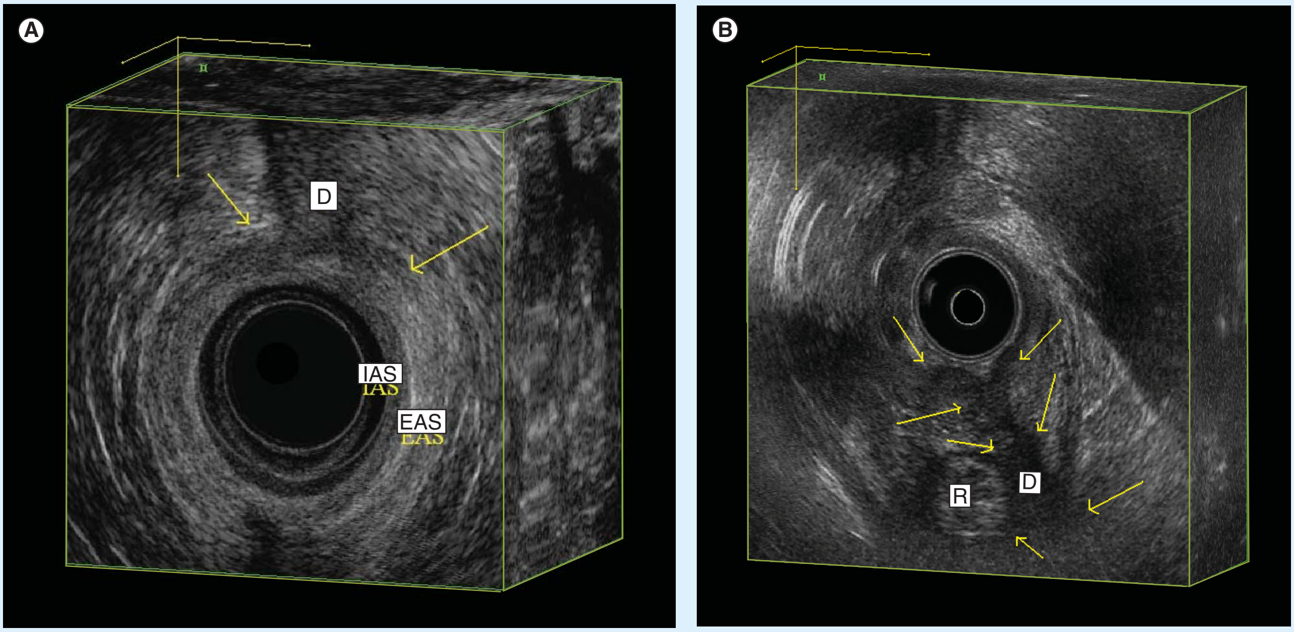

Figure 7. (A) Anterior defect after childbirth. Only a small part of the EAS is damaged anteriorly. **(B)** On the vaginal image it is clearly seen that the rupture extends from the vagina to the left lateral side of the EAS.
D: Defect; EAS: External anal sphincter; IAS: Internal anal sphincter; R: Rectum.

sphincter repair [101–103]. However, prospective studies are lacking. Reviewing the literature, three studies could not find a relationship between PNTML and anal repair [104–106]. One study found a relationship between PNTML and the results of rectopexy [107].

Establishing (the amount of) atrophy, at least in the extreme cases seems of clinical importance when selecting patients for sphincter repair. Patients with fecal incontinence due to pudendal neuropathy can be offered sacral nerve neuromodulation [108,109] even with a small sphincter defect present [110].

Diagnosing external anal sphincter atrophy

Establishing EAS atrophy has been evaluated with endoanal MRI [111–115]. Studies have demonstrated that severe atrophy of the EAS corresponded with a poor clinical outcome [105] and histopathology in biopsies (gold standard) taken from the EAS during surgery [111]. MRI criteria for atrophy are EAS thickness, EAS surface area and subjective evaluation of the amount of fat. Another study found no relationship between fat content and anorectal function [116]. One study compared the aspect of the EAS between EUS and endoanal MRI, but without 3D application and transversal or longitudinal sphincter measurements [117].

With 3D-EUS it is possible to measure EAS length on the lateral view and subsequently perform volume measurements. The high expectations of EAS volume measurements were not met, since no discrimination was found between healthy controls and patients with fecal incontinence [7]. In a subsequent study, volume measurement was found to be unsuccessful in predicting EAS atrophy in patients with fecal incontinence. Furthermore, in all patients MRI mentioned atrophy, but no histology was performed [9].

A study in 18 women with fecal incontinence compared 3D-EUS and MRI to evaluate EAS atrophy [10]. Atrophy of the EAS with EUS was judged upon its reflection of the outer interface (border of the EAS and subadventitial fat), reflection pattern and length. Atrophy was scored as none (clearly visible outer interface and mixed reflection pattern), moderate (partly visible outer interface, intermediate

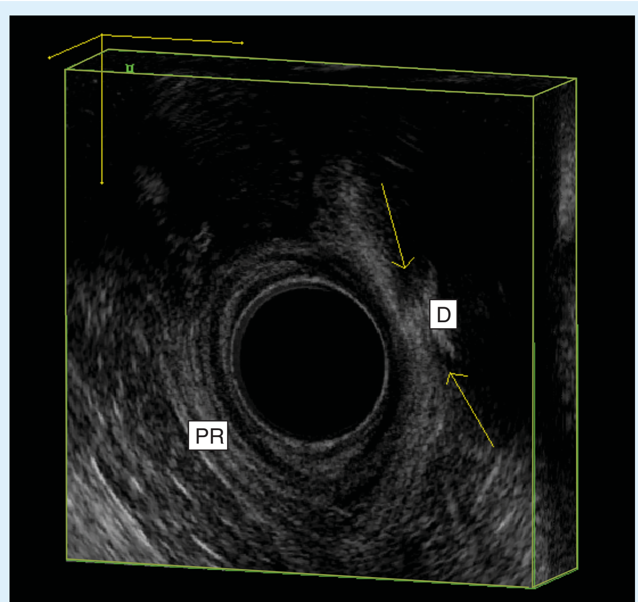

Figure 8. Defect of the PR with scarring after surgery for a high fistula. The defect is seen as a hypoechogenic area.
D: Defect; PR: Puborectal muscle.

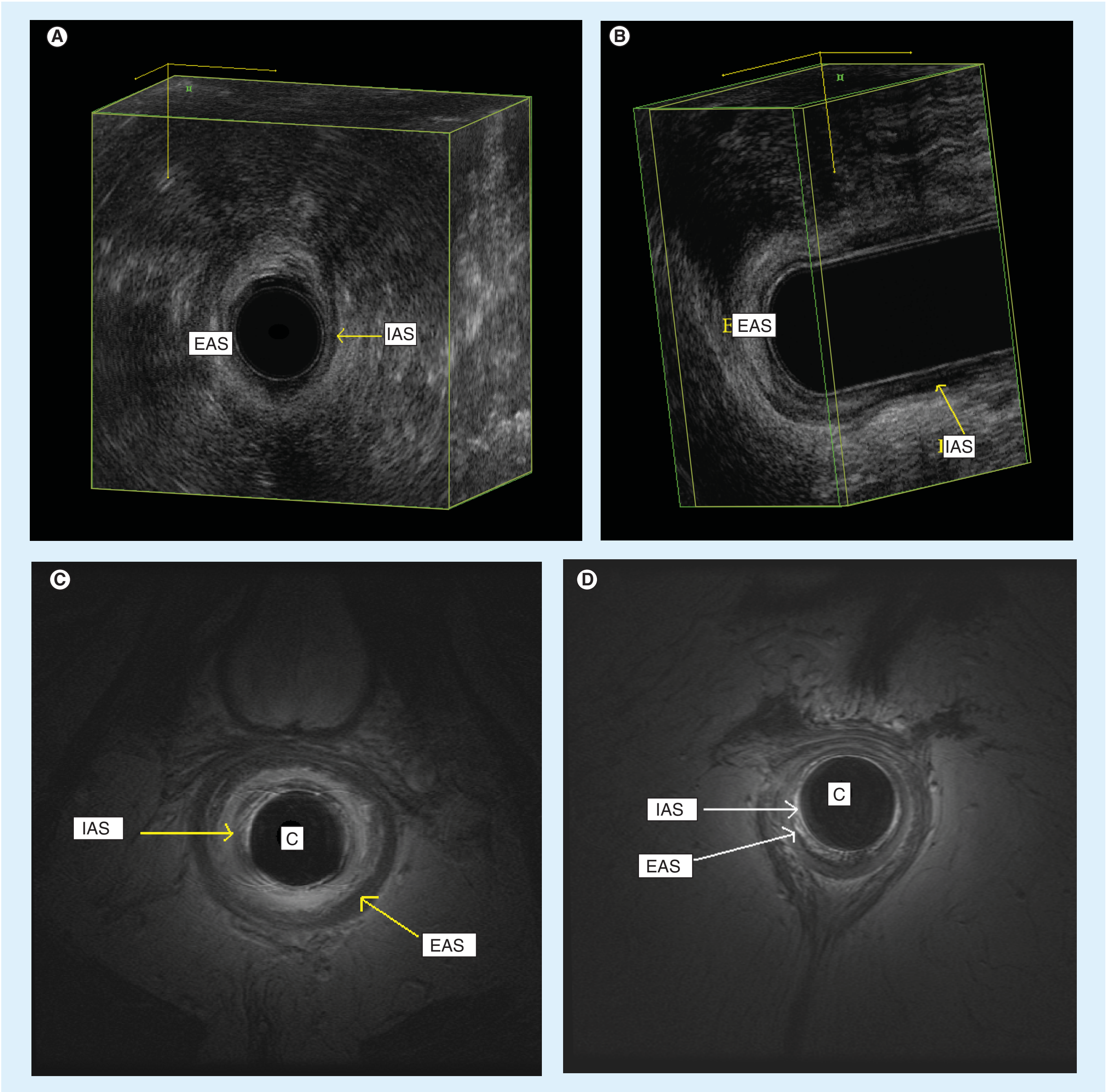

Figure 9. (A) Transversal and (B) lateral view with endoanal ultrasound of an atrophic anal sphincter. The EAS is not clearly visible as well as the IAS. **(C)** MRI of a normal sphincter and **(D)** of an atrophic shincter.
C: Endocoil; EAS: External anal sphincter; IAS: Internal anal sphincter.

reflection and moderate shortening), and severe (hardly visible outer interface, hyperechogenic reflection pattern and severe shortening) (Figures 9A & B). These criteria were derived from Williams *et al.* [116]. EAS atrophy with MRI was defined as diffuse thinning of the EAS muscle or diffuse replacement of EAS muscle by fat. EAS atrophy was graded as none (no thinning of the EAS and no replacement of EAS muscle by fat) (Figure 9C), moderate (<50% thinning of the EAS and/or replacement of EAS muscle by fat) or severe (≥50% thinning of the EAS and/or replacement of EAS muscle by fat) (Figure 9D). 3D-EUS and MRI did not significantly differ for the detection of EAS atrophy ($p = 0.25$) and defects ($p = 0.38$). 3D-EUS demonstrated EAS atrophy in 16 patients; MRI detected EAS atrophy in 13 patients. 3D-EUS agreed with MRI in 15 out of 18 patients in detecting EAS atrophy. Eight of the 18 patients scored the same grade. Both endoanal techniques were comparable in detecting EAS atrophy and EAS defects, although there was substantial difference in grading EAS atrophy. Exact thickness and length measurements do not really contribute to atrophy score. Limitations of this study

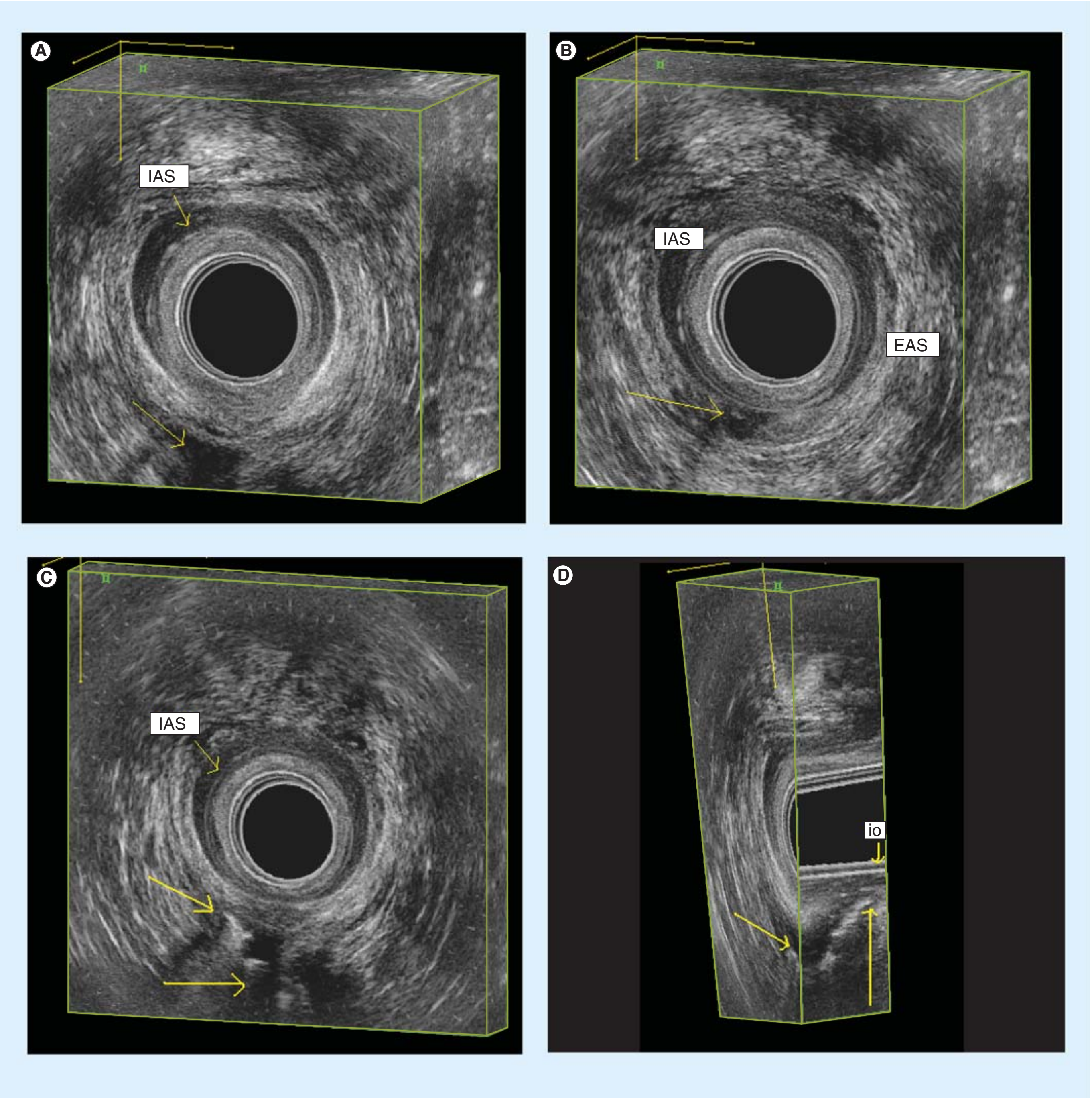

Figure 10. Perianal fistula. (A) Fypoechogenic area (arrow) suggestive for fistula tract. **(B)** After injection of hydrogen peroxide a hyperlucent area becomes visible (arrow). **(C)** The fistula tract becomes more visible. **(D)** Lateral view of the fistula tract and io.
EAS: External anal sphincter; IAS: Internal anal sphincter; io: Internal opening.

are the small number of patients and the absence of a gold standard. Furher prospective studies with more patients, healthy controls, and evaluation with surgery and histology are warranted.

Internal anal sphincter atrophy

IAS atrophy will often occur combined with EAS atrophy. Although the IAS is innervated by autonomic nerves, the same injuries can afflict both the somatic and autonomic nerves. Generally, IAS damage will lead more to soiling (leakage) of fecal fluid or mucous. Several reports have emerged concerning rare causes of fecal incontinence, such as primary IAS degeneration in passive fecal incontinence [53], IAS sclerosis in mixed connective tissue disease [78] and systemic sclerosis [84] with diffuse thinning (<0.2 mm) of the IAS. Clinical consequence is little, as no causative therapy is available, and general measurements such as defecation regulation and local hygiene are the only options.

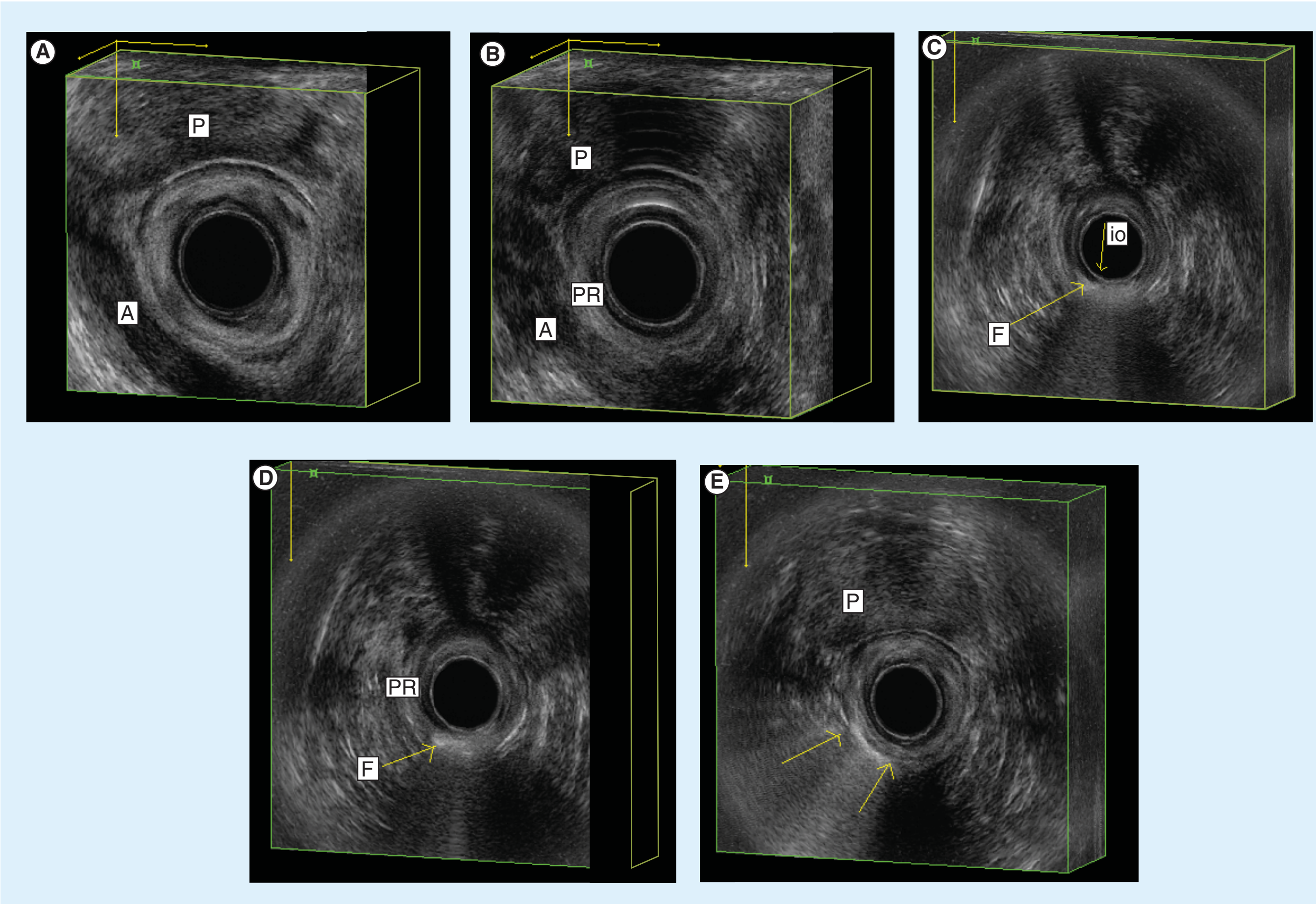

Figure 11. Perianal fistula in a patient with Crohn's disease. (A) Large hypoechogenic area, supralevatory close to the prostate and **(B)** the PR. After hydrogenperoxide the fistula tract becomes clearly visible as does the io at the level of **(C)** the anal sphincters, **(D)** the PR muscle and **(E)** the prostate.
io: internal opening; P: Prostate; PR: Puborectal muscle;

EUS versus endoanal MRI

Several studies compared the diagnostic accuracy of EUS and endoanal MRI regarding anal sphincter defects. One report suggests that EUS is superior to MRI in diagnosing IAS injury but equal in diagnosing EAS defects [117]. Interobserver agreement for sphincter defects in MRI is moderate and less than that reported for EUS [118]. Generally, detection by EUS is equal to that by MRI [30,31,119–122], although some claim MRI is superior in imaging the EAS [92,93]. EUS can be performed during surgery [123,124]. This variability can be explained by differences in study design, patient population, physician experience and interest in the techniques used. Both techniques are very reliable methods and can be used to demonstrate sphincter defects. Some reported that MRI is the preferred tool to demonstrate sphincter atrophy [113,124], but with EUS it is also possible to detect EAS atrophy, which compares well with MRI findings, as was mentioned previously [10].

EUS & anal manometry

Anal manometry can demonstrate low pressures in patients with fecal incontinence; however, there is overlap between healthy individuals and patients with incontinence [125]. Anal manometry correlates rather poorly with the presence of sphincter defects [126–130], since anal manometry reflects only the functional result, namely low anal pressures, but not the cause (sphincter defect or neuropathy). On the other hand, EUS demonstrates a sphincter defect regardless of its functional results on anal pressures. However, a large defect will result in low anal pressures. Both anal manometry and EUS are incapable of predicting clinical outcome in patients with fecal incontinence [131].

Internal anal sphincter thickness correlates with maximal basal pressure, while EAS thickness correlates with maximal squeeze pressure. Sphincter defects of IAS and EAS correlated with maximal basal and squeeze pressure, respectively [132,133]. A correlation was found between posterior sphincter length measured on 3D EUS and sphincter length measured during manometry in healthy subjects and between IAS volume and resting anal pressure in incontinent women [9].

EUS & surgery

Patients with a significant sphincter defect without clinically obvious neuropathy and/or atrophy can thus be selected for sphincter repair. EUS is also useful in selecting patients with persistent sphincter defects after failed repair [134–143]. Redo repair can improve continence [98]. Sometimes, a typical overlap sign may be observed after sphincter repair [144].

Perianal fistula

Perianal fistula can be classified acording to Parks as perianal fistulas as inter, trans, extra or suprasphincteric [145]. To reduce the risk of postoperative fecal incontinence and recurrences, it is important to identify the anatomic course of the fistula in relation to the anal sphincters and to be informed about the existence of anal sphincter defects before surgery. Furthermore, secondary extensions must be detected to reduce the risk of recurrence.

Currently, the main techniques are EUS and MRI. EUS has proved to be very valuable in delineating perianal fistulas, especially when hydrogen peroxide is used as a contrast medium (HPUS). Visualization is improved, and an accurate preoperative assessment of fistulas is obtained [146–155]. 3D EUS enables axial images of the anal canal to be reconstructed in the coronal and sagittal planes. The use of 3D images provides more information on the anatomy of anorectal disorders [11]. MRI is also very effective in preoperative assessment of perianal fistulas [156–161]. When there is doubt about the upper extent of the fistula tract or intra-abdominal abcesses, a MRI is warranted. This is especially important in patients with Crohn's disease.

EUS imaging technique

Fistula tracks can often be identified as hypoechoing tracts (Figures 10A, 11A & B). When the fistula is large, sometimes spontaneous air artifacts may be seen in the fistula tract. However, in patients with previous fistula surgery or (obstetric) trauma it may be difficult to distinguish defects and scar tissue from active perianal fistula.

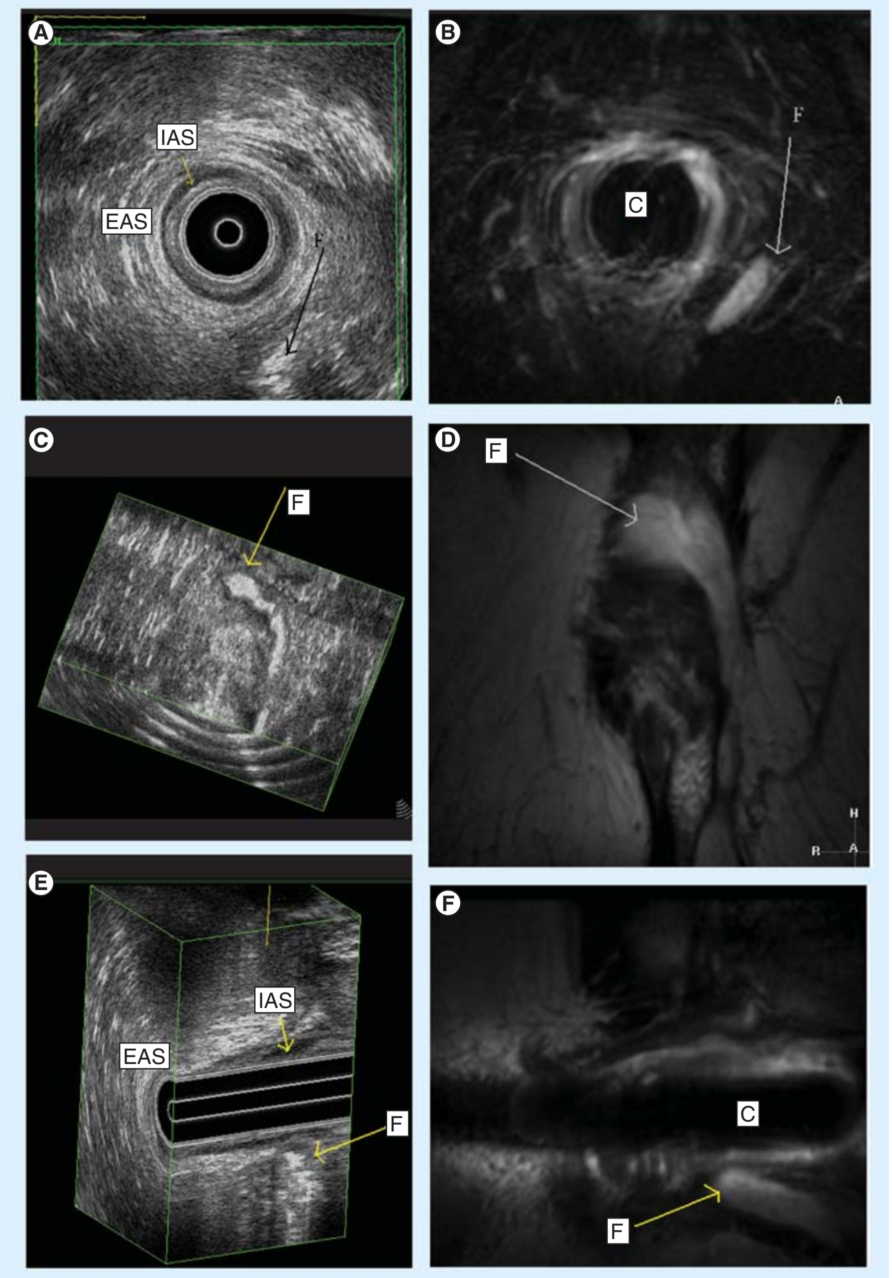

Figure 12. Perianal fistula. Comparison of EUS and MRI. **(A)** Transversal view with EUS and **(B)** MRI. **(C)** Coronal view with EUS and **(D)** MRI. **(E)** Lateral view with EUS and **(F)** MRI. C: Endocoil; EAS: External anal sphincter; F: Fistula; IAS: Internal anal sphincter.

Injecting contrast agents such hydrogen peroxide (Figures 10B–D & 11C–E) through the external fistula opening has significantly improved the results of EUS in the assessment of perianal fistulas in both the fistula tract and the internal sphincter opening [144–153]. The infusion of hydrogen peroxide generates the formation of small air bubbles and changes the fistula track from hypoechoic to bright hyperechoic ('white'). The original study described fistula tracts with HPUS in two patients, with a recurrent complex peri-anal fistula confirmed during surgery [144]. Two larger studies confirmed these results with accuracy rates of 95 [147] and 92% [153] regarding classification of the fistula during surgery. HPUS must be considered a safe, economic and reliable procedure for the assessment of perianal fistulas. Levovist has also been used to visualize perianal fistula and was better at assessing anal fistula than physical examination and conventional ultrasound [162].

Abscesses are visible as hypoechoic ('black') areas. Posterior, this should not be confounded with the echo of the anococcygeal ligament.

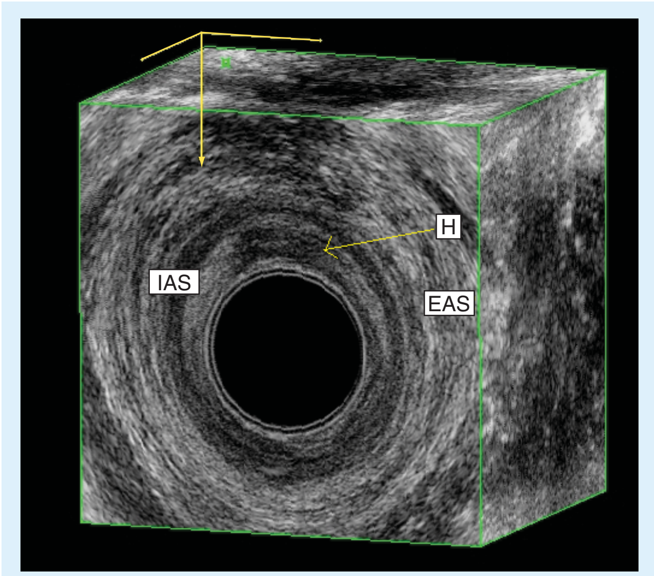

Figure 13. Hemorrhoids. The hypogenic area in the submucosa is hemorroidal tissue.
EAS: External anal sphincter; H: Hemorroidal tissue; IAS: Internal anal sphincter.

Perianal fistula patterns in cryptoglandular disease

The frequency in which Parks' fistula classification occurs and whether visualisation is necessary was examined retrospectively by reviewing all the HPUS studies to investigate the fistula track in never-operated (n = 48) and recurrent (n = 33) cryptoglandular fistulas [149]. All never-operated cryptoglandular fistulas-in-ano were inter- or trans-sphincteric. An extra track was found in 5%. Recurrent fistulas-in-ano were supra- or extrasphincteric in 15% and ramified in 27%, thus complicated in 44% of cases. Therefore, never-operated cryptoglandular fistulas-in-ano with a very small chance of complicated tracts do not require any special investigation before surgical treatment. This is in contrast to recurrent fistulas, where EUS visualization with HPUS is recommended to detect supra- or extrasphincteric fistulas or ramification, thus avoiding unnecessary damage to sphincters or missed tracks. The Goodsall rule (relationship between location of external sphincter opening and internal sphincter opening in the midanal plane) has been shown not to be accurate [163] and stresses the importance of preoperative anal ultrasound especially in complicated disease.

Perianal fistulas in Crohn's disease

In patients with Crohn's disease, EUS demonstrated that only 22% of the patients had single inter- or trans-sphincteric fistula, 12% single supra- or extrasphincteric fistula (high fistula) and 34% ramified fistula (more than one fistula track) from which the main track follows the Parks' classification but ramifications had a bizarre pattern [148]. Anovaginal fistulas were found in 32%. Thus, 78% of patients had a complicated fistula. Therefore, optimal documentation with HPUS is mandatory before surgery or immune-modulating treatments.

The effect of three infusions of infliximab (5 mg/kg) was studied in an open-label trial in eight patients with Crohn's disease-associated fistula-in-ano using HPUS [164]. Patients with vaginal or perineal fistulas did not respond clinically to therapy, whereas patients with perianal fistulas improved considerably. However, in all patients remaining fistulous tracts were demonstrated by endosonographic techniques.

These findings were confirmed in a study where 30 patients with Crohn's disease and perianal or rectovaginal fistulas were also treated with three infusions of infliximab (5 mg/kg) [165]. A total of 15 patients showed closure of their fistula at week 10, but EUS showed disappearance of fistula tracts in only five patients. Rectovaginal fistulas had a poor response (29%) compared with perianal fistulas (59%). EUS showed that patients with closed fistula had a lower recurrence rate than those with persisting fistula tracts.

In a double-blind, placebo-controlled study 24 patients were treated with three gifts infliximab (5 mg/kg) and randomly assigned to receive ciprofloxacin 500-mg twice daily or a placebo for 12 weeks [166]. At week 18, patients treated with ciprofloxacin tended to respond better. 3D-EUS improved only in three patients with a clinical response.

A retrospective study of 21 patients with Crohn's disease with perianal fistula and abscesses evaluated the effect of a clinical EUS protocol, where EUS served as a guideline for combined medical and surgical therapy [167]. Patients with infliximab (5 mg/kg), immunosupressives (6-mercaptopurine, azathioprine) and antibiotics (ciproxin) were associated with a higher and longer response rate. In addition, EUS might identify patients who can discontinue their infliximab without recurrence. Further combination of medical (immunosuppressive and immunomodulation, antibiotics) and/or surgical therapy needs to be evaluated to achieve closure of these fistulas.

Besides being of value in the assessment of fistulas and abscesses in irritable bowel disease [164–173], EUS has shown that anal wall thickness is increased in active perianal Crohn's disease [172]. Fibrosis of the anus may be visible as heterogeneity of the anal sphincter complex [171]. Bowel wall thickness has been inconsistently demonstrated. Furthermore, disease severity is a clinical assessment and is based on both clinical and imaging studies [173].

EUS compared with MRI

Several studies have compared EUS with MRI (**Figure 12**) [174–182]. One study of 21 patients determined agreement between 3D HPUS and endoanal MRI in preoperative assessment of cryptoglandular perianal fistulas and compared these results with surgical findings [166]. All had a visible external opening and underwent preoperative 3D-HPUS, endoanal MRI and surgical exploration. Experienced observers blinded for each other's findings assessed the results separately. A description of each fistula was made according to Parks (inter-, trans-, extra- and suprasphincteric; horseshoe or not classified), presence of secondary tracts (circular or linear) and location of an internal opening.

Agreement for the primary fistula tract was 81% for 3D-HPUS and surgery, 90% for endoanal MRI and surgery, as well as for 3D-HPUS and endoanal MRI. For secondary tracts, agreement for circular tracts was 67% for 3D-HPUS and surgery, 57% for endoanal MRI and surgery, and 71% for 3D-HPUS and endoanal MRI. For linear tracts, agreement was 76% for 3D-HPUS and surgery, 81% for endoanal MRI and surgery, and 71% for 3D-HPUS and endoanal MRI. Agreement for the location of an internal opening was 86% for 3D-HPUS and surgery, as well as for endoanal MRI and surgery, and 90% for 3D-HPUS and endoanal MRI. 3D-HPUS and endoanal MRI had a good agreement, especially for classification of the primary fistula tract and location of an internal opening. Both showed good agreement with surgical findings and can be used as a reliable method for preoperative evaluation of perianal fistulas.

In another study 40 patients who had not been operated on were compared concerning their 3D-HPUS and endoanal MRI findings [175] and patient preference. The methods agreed in 88% for the primary fistula tract, 90% for the location of the internal opening, 78% for secondary tracts and 88% for fluid collection. No significant difference existed between the amount of discomfort experienced or in patient preference for one procedure over the other.

Three studies found MRI to be more accurate than EUS not using HPUS [176–178]. A study in patients with Crohn's disease found EUS a more sensitive modality for imaging perianal Crohn's disease than pelvic MRI [179]; another study concluded the same with body coil MRI [180]. Others concluded that EUS, MRI and examination under general anesthesia were all accurate tests for determining fistula anatomy in patients with perianal Crohn's disease [181,182].

In most studies mentioned, surgery was used as a gold standard [174,176–178,180], although EUS and MRI are both well-established techniques for assessing fistulas. The use of surgery as a gold standard has been questioned. An EUS study demonstrated two secondary tracts with HPUS that were not found during surgery [147]. These patients developed a recurrent fistula, suggesting that these branches were actually present at the time of HPUS. In a follow-up study with 37 patients, body coil MRI was shown to make better predictions regarding patient outcome than were surgical findings [152]. Another study with 23 patients found that in two patients who did not heal after surgery, EUS showed an extension and/or abscess, which was not identified at the time of operation [180]. For body coil MRI, the corresponding number was three. In the same study, no internal opening was found during surgery in three patients.

In these studies different techniques for MRI and EUS were used [174–182]. One reason could be the use of different probes. Better results were found when a linear probe or biplane probe [179,181] was used; 3D EUS may also improve imaging [174,175]. Most studies used a body coil MRI [176,178–181]. Body coil MRI may give additional information on structures further away from the anal canal, but it can be difficult to make a distinction between fistula tracts and vessels [179]. With an endocoil, more precise information can be obtained from the anal sphincter [177,182,183].

Furthermore, hydrogen peroxide was not used in many of the comparative studies [177–182]. This is a reason for some of the disappointing results found using EUS. Excellent results have been reported for the assessment of perianal fistulas with HPUS [146–153,174,175]. The accuracy for determining the tracts can rise by 30% with HPUS [45]. A problem encountered by conventional EUS is that it is difficult to distinguish between scar tissue and active fistulas. When hydrogen peroxide is introduced into the external opening, a fistula tract appears as hyperechoic, thus identifying the fistula tract, as well as the internal opening or any secondary tracts.

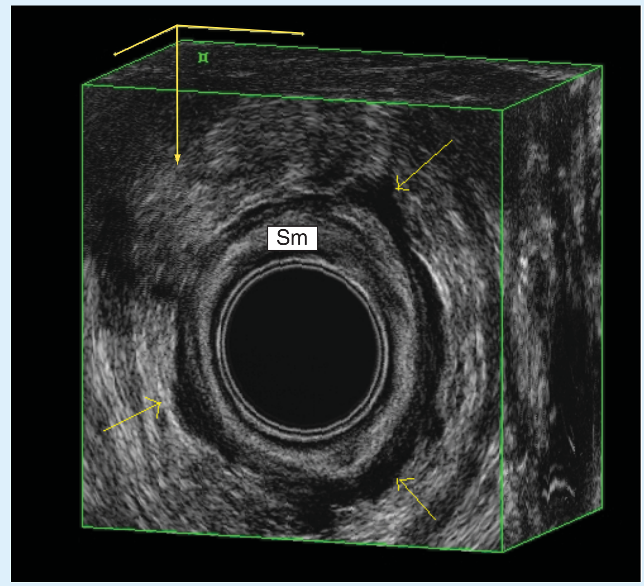

Figure 14. Anal atresia. The hypoechogenic ring (arrows) around the Sm is scar tissue where the muscularis of the rectum has been brought down into the anal canal.
Sm: Submucosa.

However, in patients with very high fistulas where the fistula or abscess cannot be followed proximal with EUS a phased array body coil MRI is indicated. In patients with anal fibrosis or severe anal pain an EUS or endoanal MRI may be impossible. In women, a vaginal approach can be an option for EUS [36]. Generally in these cases a phased array body coil MRI is indicated. EUS can be performed in patients with claustrophobia, extreme obesity and metallic implants (pacemaker) where MRI cannot be used.

Other disorders

Anal endosonography (AE) has also been performed in anorectal diseases or entities without a direct clinical impact.

Constipation

Anal endosonography has no place in the routine work-up of patients with constipation. There are two case reports describing families with a hereditary internal sphincter myopathy with a thickened internal anal sphincter with constipation and proctalgia [183,184]. In patients with obstructed defecation, abcence of relaxation of the pelvic floor can be demonstrated, but the clinical impact in addition to rectal and manometric investigation remains unclear [6,185,186]. In children [187] and patients with solitary rectal ulcer syndrome [188] thickening of the anal sphincter can be seen but, again, the basic problem here is physiological.

Anal pain

In many patients with anorectal pain a good medical history with additional physical examination abnormalities can be revealed with local inspection and proctoscopy, such as hemorrhoids, anal fissure, or small abcesses or fistula. In a small proportion of patients no underlying disease may be found at proctologic examination. Patients with anal fissures have in addition to high anal pressures a thickened IAS. These features do not differ between healing and nonhealing fissures [189] or location of the fissures [190]. However anterior fissures are associated with occult sphincter injury [191]. EUS has adds nothing more in patients with anal pain or proctalgia fugax [192] and therefore has no place in routine work-up of these patients.

Hemorrhoids

In patients with hemorrhoids the submucosa may be thickened and has a more echolucent appearance (Figure 13), suggesting the presence of fluid (i.e., blood) and is correlated with the degree of hemorrhoids [193]. Treatment of hemorrhoids with rubber band ligation or infrared coagulations does not alter anal configuration. The mucosal hemorroidal plexus is better visualized with vaginal endosonograpy (Figure 4) [194]. AE has no place in the clinical work-up in patients with hemorrhoids. It can be used in research to evaluate surgical treatment of hemorroids [194–196], where sometimes sphincterdamage damage can be established [197]. New endoscopic treatments can also be evaluated [198].

Anorectal malformations

Anal endosonography can be used to study the results after different surgical techniques and for prognosis on continence in patients with anorectal malformations (Figure 14) [199].

Expert commentary

Endoanal ultrasound has become a valuable tool in benign anorectal disease. Studies have clearly demonstrated that EUS can image sphincter defects and perianal fistulae in a perfect manner. Furthermore, more insight has been gained into the cause of fecal incontinence and the meaning of a sphincter defect. Pudendal neuropathy is not always the (only) cause of fecal incontinence. Many women with fecal incontinence appear to have a sphincter defect, while on the other hand not every sphincter defect leads to fecal incontinence. An anterior sphincter repair should only be performed when a significant defect in the EAS is present (25%). Adding hydrogen peroxide in the external fistula opening improves imaging of the fistula tract and should always be done. In recurrent fistula and fistula in patients with Crohn's disease, EUS is mandatory.

Studies comparing EUS and MRI with surgical findings demonstrate that EUS and MRI are comparable. Important is the dedication and experience of the examiner. Rectal inspection and palpation should never be omitted. The advantage of EUS is its low threshold availability by the examiner in a colorectal unit and low costs.

Five-year view

In the next 5 years we will see an increase in clinics that will perform EUS, besides having the possibility of performing anorectal MRI. Some gastroenterologists and surgeons will prefer to perform their own anal ultrasound. It is convenient as it can be performed instantly with no waiting list for MRI and is a low-budget investigation.

Endoanal ultrasound will mainly be used for patients with fecal incontinence to establish a sphincter defect and possibly sphincter atrophy, as well as being a first diagnostic in patients with perianal fistula. When fistula above the anorectal area are suspected, an additional MRI can always be performed.

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Key issues

- Endoanal ultrasound is easy to perform, has a short learning curve and causes little discomfort.
- In patients with fecal incontinence an anal sphincter defect and atrophy can be detected.
- In patients with perianal fistula the fistula tract and abcesses can be visualized. In patients with recurrent perianal fistula or with Crohn's disease additional hydrogen peroxide injection in the fistula with endoanal ultrasound improves diagnostic yield.

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