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Fecal Incontinence: Endoanal US versus Endoanal MR Imaging[1]

PURPOSE: To assess endoanal ultrasonography (US) and endoanal magnetic resonance (MR) imaging for mapping of anal sphincter defects that have been validated at surgery in patients with fecal incontinence.

MATERIALS AND METHODS: US, MR imaging, and surgical findings in 22 women with fecal incontinence who underwent sphincter repair were retrospectively reviewed. US and MR imaging had been performed before surgery. The findings were evaluated separately and validated with surgical results.

RESULTS: Endoanal MR imaging findings showed better agreement with surgical results than did endoanal US findings for diagnosis of lesions of the external sphincter (κ value, 0.85 vs 0.53) and of the internal sphincter (κ value, 0.64 vs 0.49). Endoanal US could not accurately demonstrate thinning of the external sphincter. MR imaging results correlated moderately with US results ($\kappa = 0.39$). If endoanal MR images alone had been considered, the correct surgical decision would have been made in 21 (95%) patients; if endoanal US images alone had been considered, the correct decision would have been made in 17 (77%) patients.

CONCLUSION: MR imaging is more accurate than US for demonstration of sphincter lesions. MR imaging provides higher spatial resolution and better inherent image contrast for lesion characterization. Endoanal MR imaging allows more precise description of the extent and structure of complex lesions and is superior for help in decisions about optimal therapy.

Fecal incontinence, the inability to voluntarily control the anal sphincter, may severely affect a person's quality of life and eventually lead to social isolation (1). The prevalence reported in a number of studies (2,3) has ranged from three to 10 cases per thousand but may actually be much higher. The most common causes include traumatic sphincter defects (obstetric, surgical), neurogenic dysfunction of the pelvic floor musculature, and rectal prolapse (4,5).

The main cause of fecal incontinence in women is childbirth, which can lead to mechanical or neurologic injury to the anal sphincter (6), especially the external anal sphincter. After vaginal delivery, only 0.7% of women have clinically overt sphincter damage (7). Sultan et al (8) reported that 35% of primiparous women have occult sphincter damage after vaginal delivery, and one-third of these women also have direct disturbances of anal continence. An occult sphincter defect may precipitate overt symptoms later, in middle age, as the effects of menopause (9), neuropathy, and muscle loss accumulate (10).

In treating fecal incontinence, the physician can choose from several modalities (11). Patients with sphincter damage may benefit from surgical repair (12). The choice of an optimal therapy is determined on the basis of accurate images of the anal sphincter complex. Currently, endoanal ultrasonography (US) is the preferred diagnostic technique and has replaced the invasive method of electromyography (13,14). Recently, endoanal magnetic resonance (MR) imaging was introduced and was shown to be accurate in demonstrating the anatomy of the sphincter complex (15–19).

The aim of this study was to determine which imaging technique was preferable by assessing the amount of agreement between endoanal US and endoanal MR imaging findings for mapping of external sphincter defects that had been validated with surgical results.

MATERIALS AND METHODS

Patients

Twenty-two consecutive, nonselected women (median age, 49 years; range, 22–74 years) with fecal incontinence who underwent surgical repair of the sphincter were included in this retrospective study. Informed consent was obtained from all patients, and the medical ethics committee approved the research. All of the patients were parous (median, three deliveries; range, one to eight deliveries). The degree of fecal incontinence was determined by using the grading system of Parks (20): Three patients had grade II incontinence (incontinent for flatus alone), eight had grade III incontinence (incontinent for loose stool at any time), and 11 had grade IV incontinence (incontinent for solid stool). Incontinence occurred in the women after childbirth (19 patients), anorectal surgery (two patients), or rape (one patient). All patients underwent endoanal US and endoanal MR imaging on the same day, per the standard procedure at the University Hospital Rotterdam (the Netherlands). Before US, the patients underwent limited rectal cleansing. The mean and median interval between imaging and surgery were both 189 days. The same surgeon (W.R.S.) treated all patients.

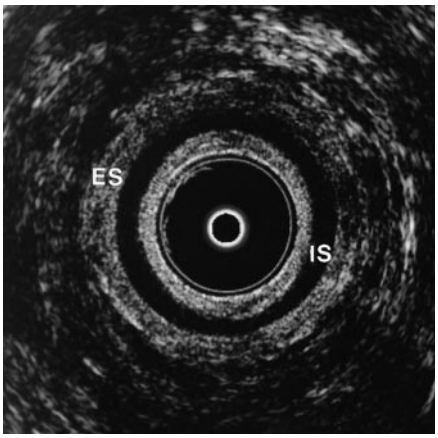


Figure 1. Axial endoanal US image shows a normal sphincter complex. *ES* = external sphincter, *IS* = internal sphincter.

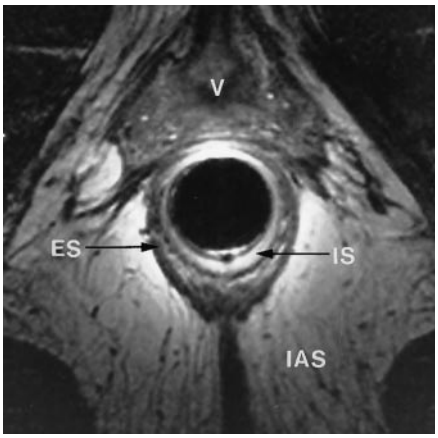


Figure 2. Axial endoanal gradient-echo MR image (30/13) shows a normal sphincter complex. *ES* = external sphincter, *IAS* = ischioanal space, *IS* = internal sphincter, *V* = vagina.

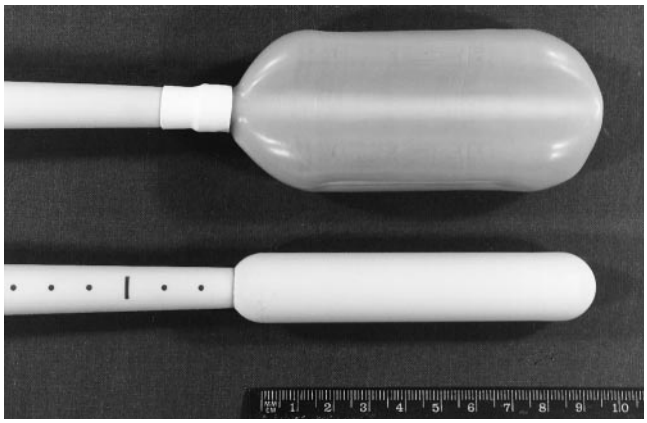


Figure 3. The endorectal coil is shown at top with a balloon. The rigid endoanal coil is shown at bottom.

Endoanal US

Endoanal US was performed with a scanner (Brüel & Kjaer, Naerum, Denmark) equipped with a rotating probe that provides a 360° image. A 7-MHz transducer with a minimum beam width of 1.1 mm and a focal length of 3 cm was used. The transducer was covered with a hard, plastic cone 18 mm in diameter. This cone was filled with degassed water for acoustic coupling and was covered with a condom after lubricant was applied to the surfaces of the condom and the cone.

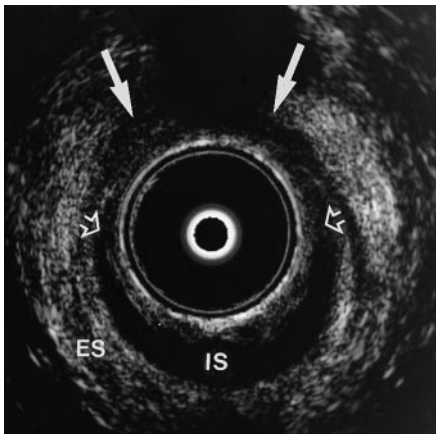
The probe was inserted into the rectum while the patient was in the left lateral position and was rotated so that the 12 o'clock position was anterior. The probe was then withdrawn until the highly reflective puborectal muscle was seen; this structure was used as the main landmark. Hard copies of axial images of the puborectal muscle and the internal and external anal sphincters were recorded at four levels in the anal canal. Figure 1 is an endoanal US image of a normal sphincter complex.

The internal sphincter appears as a symmetric ring of low reflectiveness. Any break in the continuity of this ring is abnormal and indicative of direct trauma (21,22). The external anal sphincter classically shows a fibrillar pattern of fine parallel lines that becomes more homogeneous at lower levels. Tears are defined by an interruption of the fibrillar echotexture. Scarring is characterized by loss of the normal architecture, with an area of amorphous texture that usually has low reflectiveness. The sphincter muscles may also show local thickening or thinning. Generalized external sphincter atrophy is difficult to appreciate because of the vague contours of the muscle ring.

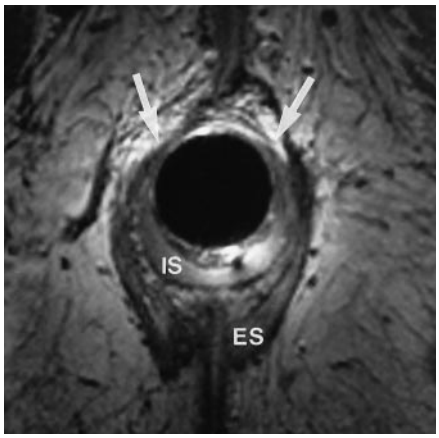
Endoanal MR Imaging

Endoanal MR imaging was performed at 1.5 T (Gyroscan ACS-NT; Philips Medical Systems, Best, the Netherlands) without bowel preparation. Figure 2 is an endoanal MR image of a normal sphincter complex. Before imaging, 1 mL of butylscopolamine bromide (Buscopan, 20 mg/mL; Boehringer Ingelheim, Germany) was injected intramuscularly to reduce bowel motion. The endoanal coil (Philips Medical Systems) (Fig 3), which was 19 mm in diameter, was covered with a condom, and lubricant was applied to the surface of the condom.

Axial three-dimensional gradient-echo MR imaging (30/13 [repetition time msec/echo time msec]; acquisition time, 6.5 minutes; flip angle, 60°; field of view , 140 × 112 mm; imaging matrix, 205 × 256; section thickness, 2 mm with contiguous sections; two signals acquired) was performed perpendicular to the long axis of the endoanal coil. For sagittal and coronal images, T2-weighted turbo spin-echo MR imaging was performed (2,800/120 [repetition time msec/effective echo time msec]; acquisition time, 5.0 minutes; echo train length, 10; echo spacing, 21.8 msec; field of view, 120 × 90 mm; imaging



a.



b.

Figure 4. (a) Axial endoanal US image in a 53-year-old woman with fecal incontinence shows a defect (solid arrows) of the external sphincter (*ES*) and a defect (open arrows) of the internal sphincter (*IS*). **(b)** Axial endoanal gradient-echo MR image (30/13) in the same patient also shows defects (arrows) of the external sphincter (*ES*) and the internal sphincter (*IS*).

TABLE 1
Endoanal US, Endoanal MR Imaging, and Surgical Diagnoses of External Sphincter Conditions

External Sphincter Condition	US Diagnosis		MR Imaging Diagnosis		Surgical Diagnosis
	Reported	Correct	Reported	Correct	
Defect	13	11	13	12	13
Scarring	5	4	5	4	4
Thinning	0	0	2	2	2
Normal	4	1	2	2	3
Total	22	16	22	20	22

TABLE 2
Endoanal US, Endoanal MR Imaging, and Surgical Diagnoses of Internal Sphincter Conditions

Internal Sphincter Condition	US Diagnosis		MR Imaging Diagnosis		Surgical Diagnosis
	Reported	Correct	Reported	Correct	
Defect	12	10	11	10	12
Scarring	1	1	1	1	1
Thinning	1	1	8	5	5
Normal	8	3	2	1	4
Total	22	15	22	17	22

matrix, 186 × 256; section thickness, 4.0 mm with an intersection gap of 0.4 mm; eight signals acquired). The coronal and sagittal sections were parallel to the long axis of the endoanal coil.

A sphincter defect was defined as a discontinuity of the muscle ring. Scarring was defined as a hypointense deformation of the normal pattern of the muscle layer due to replacement of muscle cells by fibrous tissue. Local thinning and generalized atrophy were scored on MR images.

Image Analysis

Before surgery, two radiologists evaluated the images separately: One radiologist (J.S.L.) evaluated the US images, and the other (J.S.) evaluated the MR images. Each radiologist was blinded to the results of the other technique. The decision to perform surgery was made by the surgeon on the basis of medical history, physical examination findings, and the existence of any kind of lesion of the external sphincter on MR or US images.

Because atrophy of the sphincter is not visible on endoanal US images, this condition was not considered in the correlation with MR imaging results. The quality of the images (good, moderate, or poor) and the presence, location, and type of lesions were thoroughly evaluated and recorded. The results of the imaging methods were compared with the detailed description of the surgical findings.

Statistical Analyses

Differences between US and MR imaging in the quality of images were tested with the χ^2 statistic. The categoric agreement between US, MR imaging, and surgical findings was assessed by calculating unweighted κ values. A κ value of 0.20 or less indicated poor agreement; a κ value of 0.21–0.40, moderate agreement; a κ value of 0.61–0.80, good agreement; and a κ value of 0.81–1.00, very good agreement.

In this retrospective study, all patients underwent surgery because a lesion was detected at imaging. There may have been patients with a lesion that was not detected at imaging who consequently did not undergo surgery. Therefore, the positive predictive value of the imaging techniques was considered to be a more appropriate measure than the sensitivity. The operation revealed only those parts of the sphincter that needed to be repaired. To avoid the possibility of iatrogenic incontinence, undamaged parts of the sphincter were not dissected. This rendered the negative predictive value more appropriate than the specificity. Therefore the positive and negative predictive values for detecting damage on both US and MR images were calculated.

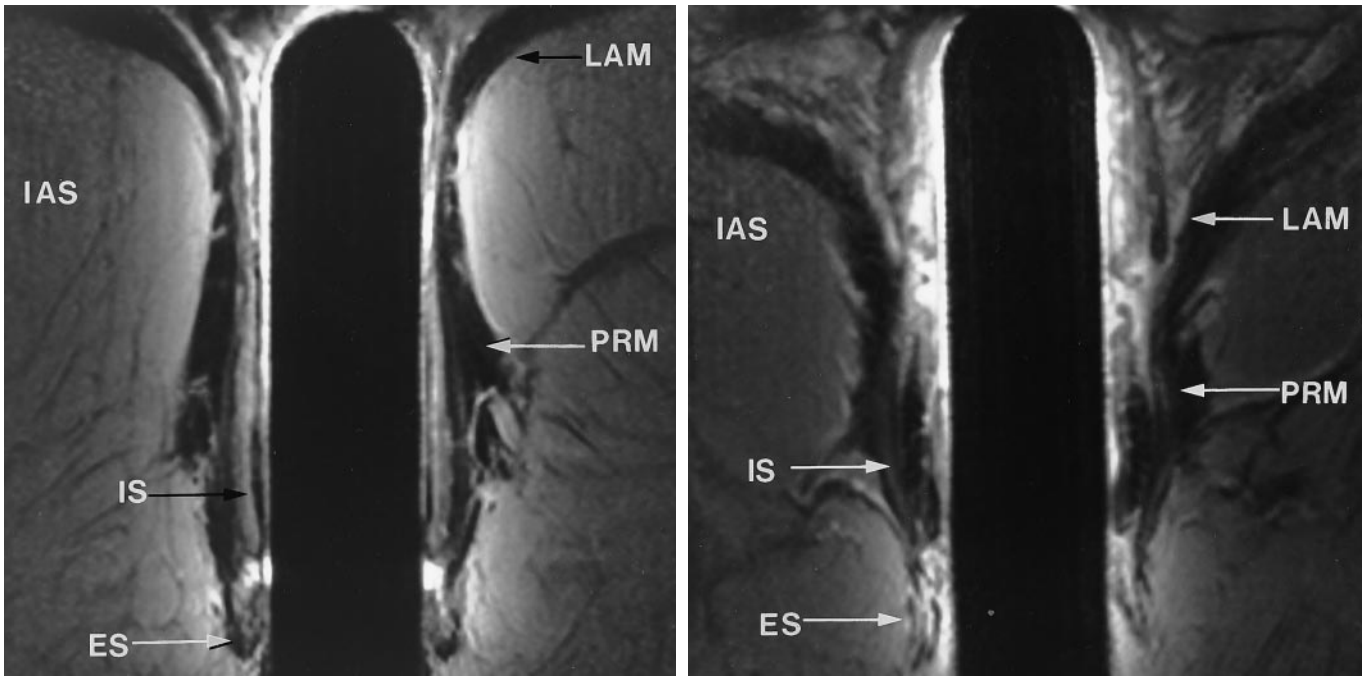
RESULTS

Image Quality

The quality of the US images was good in 17 (77%) of 22 patients, moderate in two (9%), and poor in three (14%). The quality of the MR images was good in eighteen (82%) patients, moderate in three (14%), and poor in one (4%). The differences in image quality between US and MR imaging were not statistically significant (χ^2 test for comparison, $P = .5$; χ^2 test for trend, $P = .6$). No disturbing artifacts were present on the images.

External Sphincter

At surgery, an external sphincter defect was detected in 13 patients; isolated scarring, in four patients; and local thinning



a. b.

Figure 5. (a) Coronal T2-weighted turbo spin-echo endoanal MR image (2,800/120 [effective]) in a 46-year-old woman with a normal anal sphincter. The external sphincter (*ES*), internal sphincter (*IS*), puborectal muscle (*PRM*), and levator ani muscle (*LAM*) are shown. *IAS* = ischioanal space. **(b)** Coronal T2-weighted turbo spin-echo endoanal MR image (2,800/120 [effective]) in a 61-year-old woman with atrophy of the external sphincter (*ES*). *IAS* = ischioanal space, *IS* = internal sphincter, *LAM* = levator ani muscle, *PRM* = puborectal muscle. Scarring causes low signal intensity in the internal sphincter.

of the sphincter, in two patients. Three patients had a normal sphincter. An external sphincter defect was correctly assessed at endoanal US in 16 (73%) of 22 patients, which was indicative of moderate agreement with surgical results (κ = 0.53) (Fig 4a). An external sphincter defect was correctly assessed at endoanal MR imaging in 20 (91%) patients, which was indicative of very good agreement with surgical results (κ = 0.85) (Fig 4b). At surgery, the position of one defect was different from that seen at MR imaging, and the imaging-determined position was considered to be incorrectly reported. External sphincter atrophy was detectable only with MR imaging and was seen in nine patients, in whom atrophy was confirmed at surgery (Fig 5). The surgeon did not find external sphincter atrophy in any patient in whom atrophy was not detected on MR images. The distribution of reported and correct diagnoses for the imaging techniques is shown in Table 1.

In this retrospective study, the decision to perform surgery was based on the presence of any kind of lesion of the external sphincter (defect, scar, or thinning) as seen on MR or US images. In this regard, there were no false-negative MR images and one false-positive MR image (Fig 6). US images were false-negative in three patients and false-positive in two. If MR imaging findings alone had been considered, the correct decision would have been made in 21 (95%) of 22 patients; if US findings alone had been considered, the correct decision would have been made in 17 (77%) patients.

Internal Sphincter

At surgery, an internal sphincter defect was found in 12 patients; local thinning, in five; isolated scarring, in one; and a normal sphincter, in four. On the basis of endoanal US findings, thinning was correctly reported in one patient and incorrectly reported as a normal internal sphincter in three patients and as a defect in one patient. All cases of thinning found at surgery were seen on MR images. In three additional patients, thinning was seen on MR images but was not validated at surgery. Endoanal US results were indicative of a correct diagnosis in 15 (68%) of 22 patients (Fig 4a); the agreement with surgical results was moderate (κ = 0.49). Endoanal MR imaging results were indicative of a correct diagnosis in 17 (77%) patients; the agreement with surgical results was good (κ = 0.64) (Fig 4b). The distribution of reported and correct diagnoses for the imaging techniques is shown in Table 2.

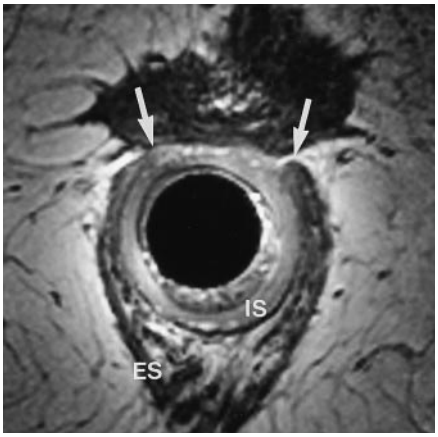
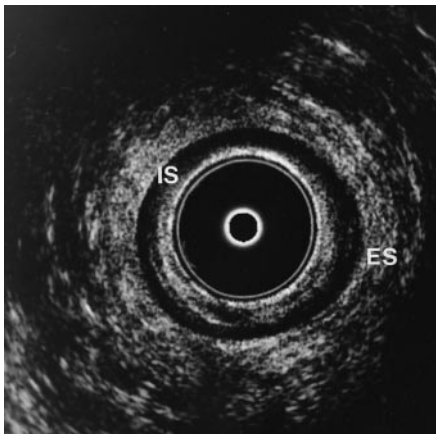


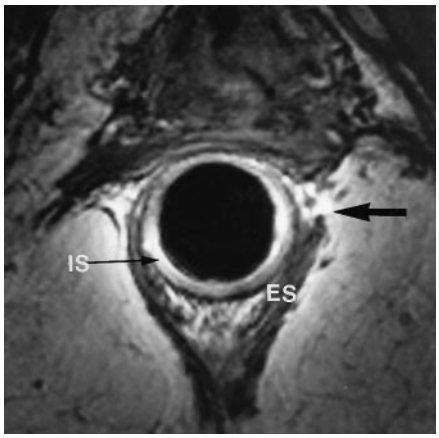
Figure 6. Axial endoanal gradient-echo MR image (30/13) in a 40-year-old woman with fecal incontinence shows a subtle decrease in signal intensity and altered texture (arrows) of the external sphincter (*ES*). These findings were suggestive of a diagnosis of scarring. Surgical results did not validate this diagnosis. *IS* = internal sphincter.

Agreement between US and MR Imaging Results

For the diagnosis of the external sphincter conditions (defects, scarring, thinning, or normal), endoanal US findings



a.



b.

Figure 7. (a) Axial endoanal US image in a 41-year-old woman with fecal incontinence shows no evidence of a lesion of the external sphincter (*ES*) or the internal sphincter (*IS*). At surgery, an external sphincter defect was found. **(b)** Axial endoanal gradient-echo MR image (30/13) in the same patient shows the defect (thick arrow) of the external sphincter (*ES*), which was validated with surgical results. The internal sphincter (*IS*) is normal on the MR image, and this finding was confirmed at surgery.

corresponded with endoanal MR imaging findings in 14 (64%) of 22 patients, which was indicative of fair to moderate agreement ($\kappa = 0.38$) (Fig 7). For mapping of internal sphincter damage, results from the two imaging techniques corresponded in 13 (59%) of 22 patients, again indicative of fair to moderate agreement ($\kappa = 0.39$).

Atrophy or thinning of the sphincter could not be correctly detected with endoanal US. The positive and negative predictive values for each diagnostic method for the demonstration of damage (excluding atrophy or thinning) of the external and internal sphincters are given in Table 3.

TABLE 3
Predictive Values of US and MR Imaging for Demonstration of Damage to the External and Internal Sphincters

Sphincter and Value	US	MR Imaging
External		
Positive predictive value	15 of 18 (83)	18 of 20 (90)
Negative predictive value	1 of 4 (25)	2 of 2 (100)
Internal		
Positive predictive value	12 of 14 (86)	16 of 20 (80)
Negative predictive value	3 of 8 (38)	1 of 2 (50)

Note.—Number in parentheses is the percentage.

For conditions of the external sphincter, MR imaging findings yielded good positive and negative predictive values, both higher than those of US findings. For conditions of the internal sphincter, the imaging techniques yielded comparable predictive values.

The positive predictive values for demonstration of any damage to the anal sphincter complex (external or internal sphincter) were 89% (32 of 36) for US and 95% (38 of 40) for MR imaging. Likewise, the negative predictive values were 25% (two of eight) for US and 100% (four of four) for MR imaging. Endoanal MR imaging results showed good agreement with surgical results ($\kappa = 0.75$), whereas US results showed moderate agreement ($\kappa = 0.52$).

DISCUSSION

Patients with fecal incontinence who may benefit from surgical therapy are selected on the basis of the detection and type of sphincter damage. To perform optimal surgery, an accurate description of the position, extent, and type of lesion is necessary. In previous studies (22), endoanal US findings validated with surgical results have been shown to be more accurate than findings from electromyography and manometry for the diagnosis of fecal incontinence. Other authors (23) have reported that endoanal US was also superior to MR imaging with a body coil for evaluation of the anatomy of the sphincter.

The limitation of endoanal US, however, is poor inherent contrast on images, which makes characterization of the external anal sphincter difficult. Surgery often damages this anal muscle, which is of major importance for continence. The recently developed technique of endoanal MR imaging produces images with high inherent contrast and high spatial resolution and enables detailed demonstration of normal sphincter anatomy and pathologic conditions (muscle tears, abscesses, fistulous tracks, scars, atrophy, and hypertrophy) (24). In a study (25) with seven patients who had obstetric sphincter trauma, endoanal MR imaging findings validated with surgical results provided a 100% accurate description of the site and extent of the sphincter tears.

Our aim, therefore, was to select the best imaging technique for the work-up in patients with a sphincter defect. To our knowledge, this is the first study in which endoanal MR imaging and endoanal US have been directly compared in relation to surgical findings in patients with fecal incontinence. In our study, the sphincter lesion in all but three patients was the result of childbirth. The position of the majority of lesions, therefore, was anterior. In the three patients with a lesion not caused by childbirth, the position of the lesion also was anterior. The surgical technique (anterior anal repair) allowed a good description of the lesion, which was used as the reference standard for the comparison between the two imaging methods.

Lesion Detection

For the detection of lesions, MR imaging findings showed very good agreement with surgical results as regards the external sphincter and good agreement as regards the internal sphincter. US findings showed moderate agreement with surgical results for detection of lesions of both the external sphincter and the internal sphincter. The correlation between MR imaging and US findings was moderate.

The negative predictive value of both techniques was relatively low. This can be explained by the fact that our study included a small number of patients with lesions that could not be detected on either on MR or US images. If, for instance, the lesion in one additional pa-

tient could have been detected on MR images, the negative predictive value of MR imaging would have doubled. Further study with a larger number of patients will result in a more accurate determination of the negative predictive value. Nevertheless, MR imaging yielded a combination of high positive and negative predictive values for lesions of the external sphincter, which suggests that MR imaging is a good preoperative diagnostic method in patients who require anterior sphincter repair.

Lesion Characterization

US and MR imaging were comparable with regard to characterization of damage to the internal sphincter. With regard to characterization of damage to the external sphincter, however, endoanal MR imaging allowed good distinction among different types of tissue (muscle, scar, fat). This facilitated accurate detection of local thinning, which was not possible with US, and more precise description of the extent and structure of complex lesions. In a recent study (26), it was shown that thinning and atrophy of the external sphincter seen on endoanal MR images is predictive of the outcome of anterior sphincteroplasty.

Surgical Decision Making

The two imaging techniques were complementary with regard to surgical decision making. The advantage of US is that it is a cheaper, more widely available, and quicker technique than MR imaging. Nevertheless, if only one technique is to be used, then MR imaging findings will result in the optimal decision more often than will US findings. This could prevent unnecessary surgery and may make MR imaging cost-effective.

A prospective study is currently underway to assess all the aspects presented in this report. In the current study, the use of endoanal MR imaging findings was superior to the use of endoanal US findings with regard to decisions about the optimal therapy.

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