Magnetic Resonance Imaging

34

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Learning Objectives

- Recognize the imaging features of fecal incontinence.
- Describe the accuracy, advantages and disadvantages of EAUS and MRI.
- Identify sphincter defects and atrophy on MRI.

34.1 Introduction

The workup of patients with fecal incontinence primarily comprises clinical history, physical examination, anofunctional tests (e.g., manometry), and endoanal ultrasound (EAUS). Magnetic resonance imaging (MRI) was introduced in the 1990s as an alternative for EAUS. The primary reason was the difficult delineation of the external sphincter at EAUS. MRI has a high intrinsic contrast resolution, which has proved to be beneficial for delineating the external sphincter. In this chapter the role of MRI in patients with fecal incontinence is described. As treatment is primarily aimed at the external sphincter, the emphasis is on evaluation of the external sphincter.

34.2 Technique

34.2.1 MRI Coil

In patients with fecal incontinence, MRI has primarily been studied using an endoluminal coil. The advantage of a dedicated coil is the high signal to noise ratio (SNR) close to the coil. This high SNR can be used for obtaining images with high spatial resolution. As the anal sphincter muscles are only a few millimeters thick, optimal spatial resolution is advantageous. The distension caused by the coil could be considered a disadvantage, as the anal sphincter components are stretched. Although some thinning will occur which might be disadvantageous, the information obtained by the high spatial resolution of an endoanal coil will more than compensate for this. Subtle changes in the architecture of anal sphincter components and in signal intensity are visible. It is possible that some distension might be beneficial to visualize a sphincter defect. This will occur as overlapping torn sphincter parts are displaced, which may help in identifying the defect.

Our experience is based on a 17 mm cylindrical coil with a length of 8 cm. The coil is protected by a 19 mm outer diameter coil holder, which has a length of 10 cm [1]. The diameter of the endoanal coil is comparable to the diameter of an endosonography transducer, facilitating comparison of findings.

34.2.2 Preparation

The coil we use is a multiple-use coil (we use the coil in hundreds of examinations), and appropriate hygienic measures are taken (including disinfectant) for each procedure. A condom covers the coil and some lubricant is applied. It is introduced in the left lateral position. After careful positioning of the coil, the patient turns to a supine position, and prior to imaging the coil position is checked.

To prevent artifacts of peristalsis, we ask patients not to eat or drink for 4 h prior to the examination, and we use a bowel relaxant (butylscopolamine bromide, Buscopan, Boehringer, Ingelheim, Germany). When butylscopolamine bromide is not approved for this application (such as in the USA), glucagon can be used as an alternative. However, glucagon is more effective for reducing small bowel peristalsis

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G. A. Santoro et al. (eds.), *Pelvic Floor Disorders*, https://doi.org/10.1007/978-3-030-40862-6_34

than large bowel contractions. For further reduction of artifacts, we ask patients not to squeeze their anal sphincter, pelvic floor muscles, or gluteal muscles during the examination. As endoanal MRI is highly sensitive to motion artifacts, we position the patients as comfortable as possible using supportive material, including supporting the legs so that patients can be as relaxed as possible.

34.2.3 Imaging Protocol

A practical imaging approach comprises an axial oblique and coronal oblique moderately T2-weighted turbo spin-echo sequences (TSE) (at 1.5 T TR 2500 ms; TE 70 ms). These imaging sequences are angulated at the anal axis for optimized visualization of the anal sphincter muscles.

In patients with fecal incontinence, the endoanal MRI procedure is well tolerated and probably comparable to that at EAUS [2]. Endoanal MRI is more time-consuming than EAUS (approximately 30 min vs. 10 min room time).

When visualization of the complete pelvic floor is needed, or dynamic information about the pelvic floor, additional sequences with an external coil are mandatory.

Although experience is limited, the anal sphincter can also be studied with external phased array coils [3]. External coil MRI is less intrusive and uncomfortable for the patient and can therefore be a valuable alternative. This is especially advantageous as it can be performed with almost any MRI machine in only 15 min. Experienced readers achieve comparable results to endoanal MRI for external sphincter defects and external sphincter atrophy [4, 5]. To our knowledge, no recent studies have compared endoanal MRI to external coil MRI.

34.3 MRI Findings

External sphincter lesions primarily concern local defects and scarring. A defect is demonstrated as a discontinuity of the external sphincter, often with some scar tissue (Fig. 34.1). More frequently, no conspicuous defect is visible, but normal sphincter tissue is replaced by scar tissue. Scar tissue can be recognized as tissue with low signal intensity (relative black) and disturbed architecture. Normal anal sphincter tissue has a multilayered appearance, which is distorted by the scar tissue. Identification of subtle scar tissue is facilitated by scar tissue in the fat containing ischioanal space, directly adjacent to the external sphincter (Fig. 34.2). The external sphincter can either be thickened, thinned, or of approximately normal thickness at the area of scar tissue. Internal sphincter defects have a similar appearance, although scar tissue can be somewhat less hypointense (Fig. 34.3). However, the normal internal sphincter has high signal intensity, and therefore there is considerable contrast between scar tissue and normal internal sphincter.

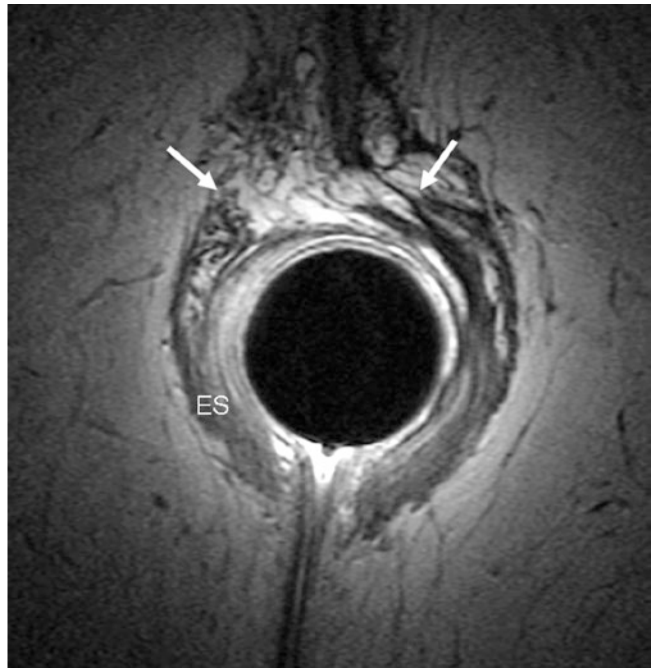

Fig. 34.1 Endoanal axial T2-weighted turbo spin-echo in a 50-year-old female patient with severe fecal incontinence. She had a history of a complete rupture and episiotomy with primary repair. MRI shows an anterior external sphincter defect (*arrows*). The edges and adjacent parts of the torn external sphincter are fibrous (scar tissue) with distorted architecture and low signal intensity (compare to posterior part of external sphincter (*ES*))

Interobserver agreement of endoanal MRI for sphincter defects is best when the sphincters are either both intact or both disrupted [6]. For individual sphincters, interobserver agreement for defects is fair (external anal sphincter) and moderate (internal anal sphincter) [6]. A study in 30 patients reported moderate to good interobserver agreement for external sphincter defects [4]. Intraobserver agreement was fair to very good and depended upon experience.

Generalized atrophy of the external sphincter can present as either thinning, fatty replacement, or—most frequently—both. Measuring the external sphincter thickness is helpful. However, visual evaluation of the presence of fat is important, as in some patients fascial borders remain intact while the muscle bulk is greatly reduced (Fig. 34.2).

With ageing, there is a physiological thinning of the external sphincter. At endoanal MRI, the external sphincter is 4.32 mm in women aged 35 years or younger and 3.9 mm in women older than 65 years [7]. In men the values are 5.21 and 3.45 mm, respectively. Internal sphincter atrophy is visible as thinning of the internal sphincter. With ageing, there is a physiological thickening of the internal sphincter. These physiological changes of the external and internal sphincter were also demonstrated at EAUS [8]. An internal sphincter

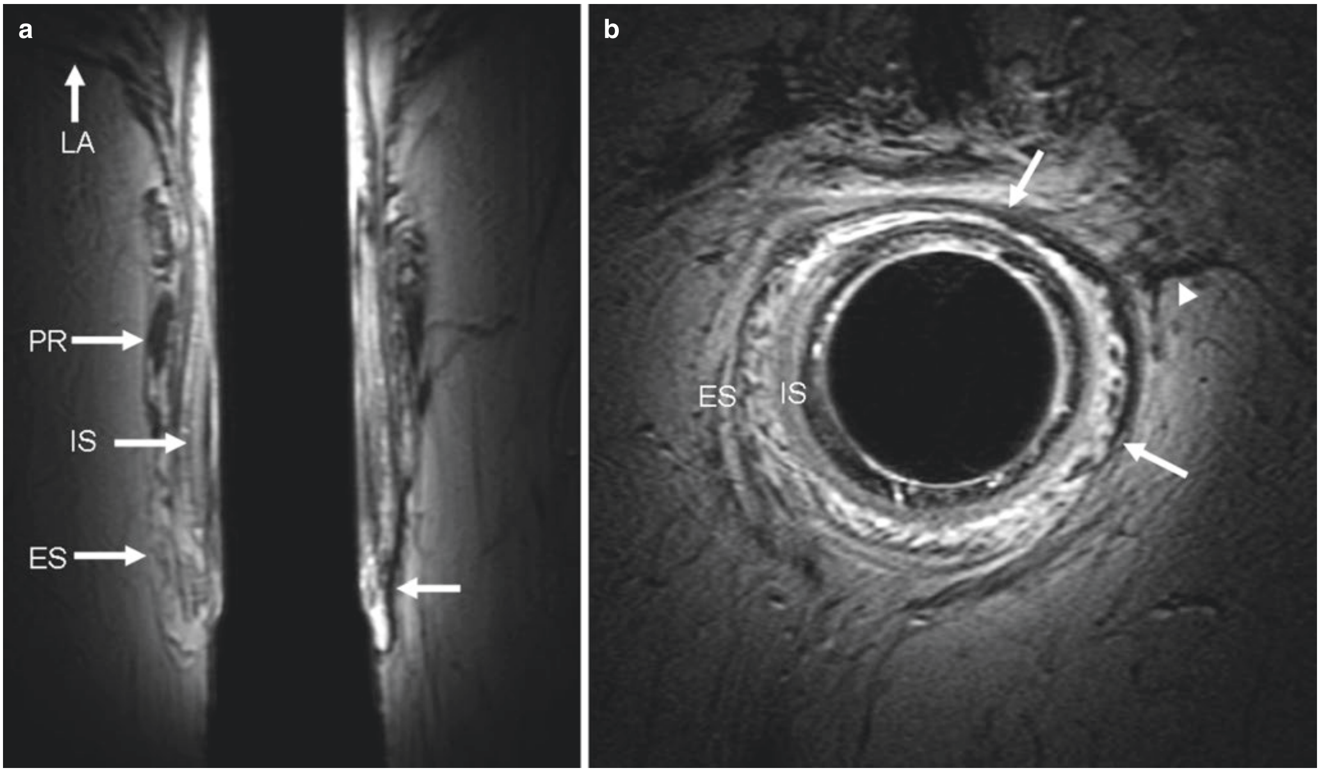

Fig. 34.2 Endoanal coronal (**a**) and axial (**b**) T2-weighted turbo spin-echo in a 56-year-old female patient with fecal incontinence show severe atrophy of the external sphincter (*ES*) and scar tissue of the left anterolateral external sphincter (*arrows*) with adjacent scar tissue in the ischioanal space (*arrowhead*). There is also atrophy of the internal sphincter (*IS*) and moderate atrophy of the puborectal muscle (*PR*) and levator ani (*LA*). Compare to Fig. 34.3

with a thickness less than 2 mm, in a middle-aged or elderly individual, is considered atrophied (Fig. 34.2).

34.4 Accuracy for Sphincter Defects

In the more than 20 years since the introduction of endoanal MRI, several studies have been published on the accuracy of endoanal MRI in detecting anal sphincter defects. Initial studies concerned rather small series, demonstrating that accuracy is good (up to 95%) for demonstrating external sphincter defects [9, 10]. As EAUS is the standard technique for demonstration of anal sphincter defects, a comparison of endoanal MRI and EAUS is important. Two single-center studies and one larger multicenter comparative study have been performed.

The first comparative study retrospectively compared both techniques to findings at surgery. The study concerned 22 patients with fecal incontinence undergoing anterior anal sphincter repair [11]. There was better agreement of endoanal MRI with surgical results for external sphincter defects compared to findings at EAUS for diagnosing lesions of the external anal sphincter (κ MRI 0.85 vs. EAUS 0.53) and internal anal sphincter (κ MRI 0.64 vs. EAUS 0.49).

These findings were not confirmed in a prospective study in a larger number of patients. In this study, findings at EAUS and endoanal MRI in 52 patients were compared to the final diagnosis made by an expert panel, based on all available information [12]. Complete agreement between endoanal MRI and EAUS and the final diagnosis was found in 62%. Findings at EAUS were more frequently confirmed by the expert panel than findings at endoanal MRI. Discordant findings primarily concerned internal sphincter lesions. The authors concluded that MRI is inferior in diagnosing internal anal sphincter injury. The differences between both studies are probably related to differences in experience with either technique and differences in the disease spectrum and reference standard.

The third study compared EAUS and endoanal MRI for detection of external sphincter defects [13]. This multicenter study concerned 237 patients (214 women). There was agreement between endoanal MRI and EAUS in 146 patients (61%; $\kappa = 0.24$: fair agreement). A selection of patients ($n = 36$) underwent anterior anal sphincter repair. In these patients there was no significant difference in the detection of external anal sphincter defects between endoanal MRI and EAUS ($P = 0.23$). The sensitivity and positive predictive value of endoanal MRI were 81% and 89%,

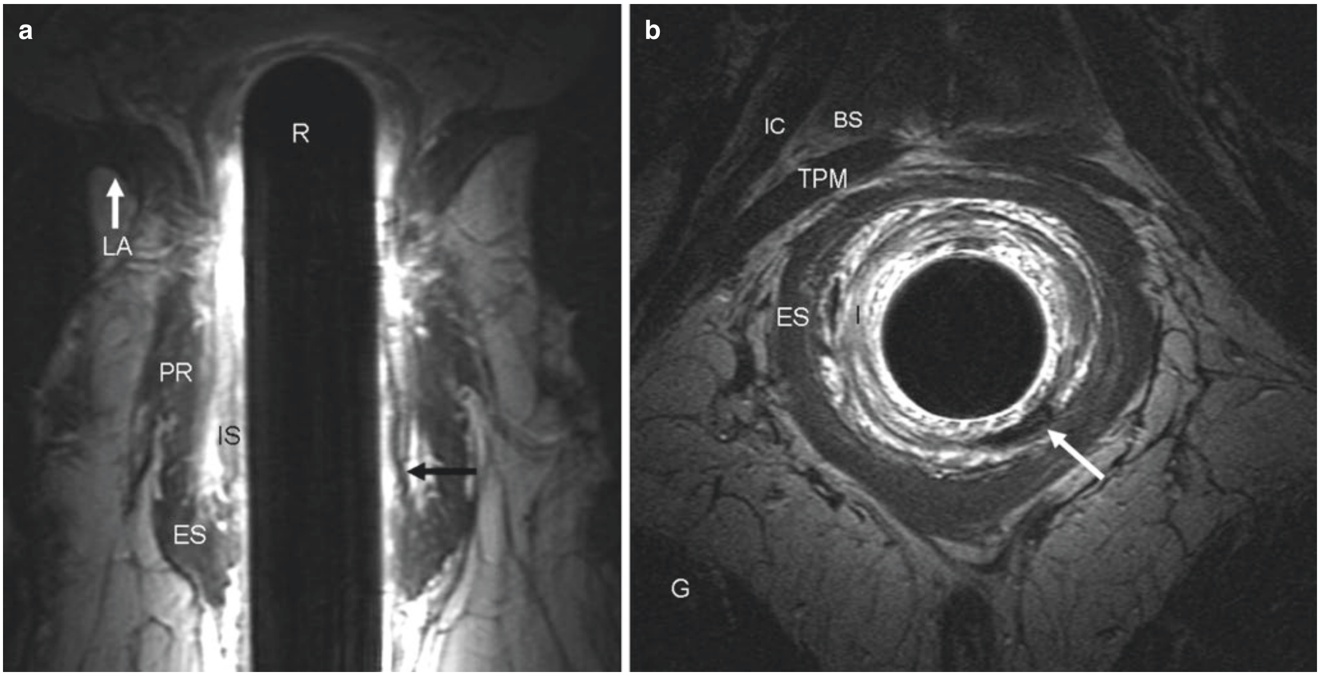

Fig. 34.3 Endoanal coronal (**a**) and axial (**b**) T_2-weighted turbo spin-echo in a 46-year-old male patient with anal pain demonstrates normal anatomy of the external sphincter (*ES*) and puborectalis muscle (*PR*) at the right side. The inferior part of the internal sphincter (*IS*) is abnormal (best seen in the axial plane (**a**); compare to Fig. 10.5), with disturbed architecture of the complete inferior internal sphincter ring and scar tissue of the internal sphincter left posterolateral (*black arrow in* **a**; *white arrow in* **b**) after previous surgery. *BS* bulbospongiosus muscle, *G* gluteus musculature, *IC* ischiocavernosus muscle, *LA* levator ani (*white arrow* in **a**); *TPM* transverse perineal muscle, *R* coil with tip in distal rectum

respectively, and 90% and 85%, respectively, for EAUS). Based on these three studies, one can conclude that EAUS and endoanal MRI are comparable in the detection of external sphincter defects.

Obstetric trauma is considered to be a major cause of sphincter defects. These sphincter defects may coincide with defects of other pelvic floor muscles, which may also result from obstetric trauma. In a study of 105 severe fecal-incontinent patients, defects of the puborectal muscle or levator ani were identified [14]. These defects were rarely solitary findings but associated with internal or external sphincter defects in these patients presenting with fecal incontinence. Atrophy of the puborectal muscle or levator ani muscle almost always coincided with external sphincter atrophy.

In patients who have experienced unsuccessful anterior anal repair, imaging can be performed to identify the cause of the failure. A study with 30 patients with fecal incontinence has shown that at endoanal MRI, patients with a visible overlap and less than 20% fat tissue had a better clinical outcome (Fig. 34.4) [15]. Further, preserved external sphincter thickness correlated significantly with better surgical outcome (see Sect. 34.5 on sphincter atrophy). Residual external sphincter defects were better demonstrated at EAUS, which might be related to the rather limited experience with post-surgical endoanal MRI. To our knowledge, MRI has not been studied in evaluating other surgical treatments.

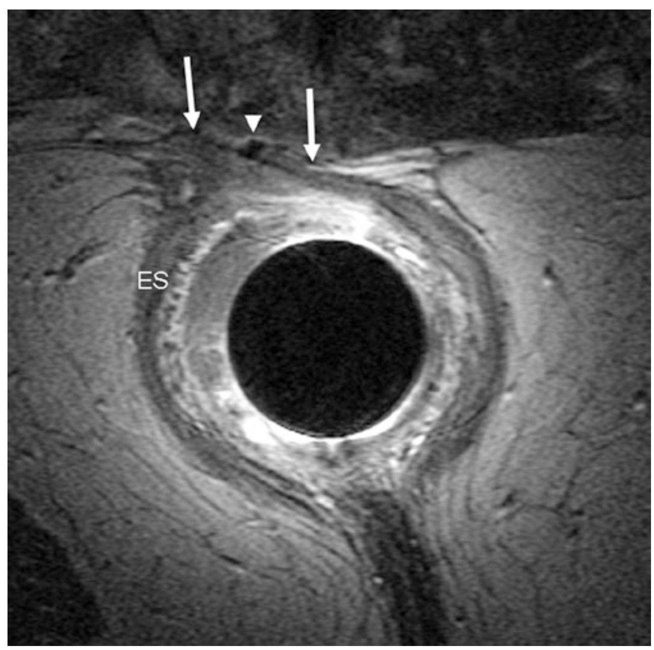

Fig. 34.4 Endoanal axial T2-weighted turbo spin-echo in a 34-year-old female patient with fecal incontinence. She had a complete rupture 4 years earlier and underwent anterior anal repair for an anterior external defect at EAUS. Fecal incontinence had not improved after anterior anal repair. At endoanal MRI there is reasonable left-over-right overlap of the external sphincter parts (*arrows*). There is some atrophy of the external sphincter. Susceptibility artifact anterior (*arrowhead*). *ES* external anal sphincter

34.5 Accuracy for Sphincter Atrophy

External sphincter atrophy was a finding known from electromyography. This entity had become somewhat neglected following the widespread replacement of electromyography by EAUS.

As the external sphincter is very well delineated at endoanal MRI, detection of atrophy was an easy task (Fig. 34.2). A study with histopathological verification in 25 patients demonstrated that endoanal MRI is accurate in detecting external sphincter atrophy [16]. Endoanal MRI had a sensitivity of 89%, specificity 94%, positive predictive value 89%, and negative predictive value 94% for external sphincter atrophy.

External sphincter atrophy is a finding related to sphincter function. In a prospective series of 200 patients, external anal sphincter atrophy was present in 123 patients (62%) at endoanal MRI [17]. The atrophy was severe in 44 patients (22%) and mild in 79 (40%). Maximal squeeze pressure and squeeze increment pressure were significantly decreased in individuals with external sphincter atrophy. Patients with severe atrophy had a significantly lower maximal squeeze and squeeze increment pressure than patients with mild atrophy. This is concordant with an earlier study in which 16 patients with fecal incontinence and decreased squeeze pressure, and 9 controls with normal squeeze pressures, were studied [18]. Anal squeeze pressure correlated with external sphincter volume and fat content.

Two studies have evaluated the role of endoanal MRI in predicting the outcome of anterior anal repair. One study performed endoanal MRI in 20 female patients scheduled for anterior anal repair. Eight of these patients had external sphincter atrophy. The outcome was significantly better in those patients without external sphincter atrophy [19]. A further study in 30 patients demonstrated that baseline measurement of preserved external anal sphincter bulk correlated with a better outcome [15]. These studies demonstrate that external sphincter atrophy at endoanal MRI is a negative predictor of outcome of anterior sphincter repair.

Studies on EAUS and detection of external sphincter atrophy are sparse and have limited patient numbers and conflicting results. In a comparative study of 20 female patients, external sphincter atrophy was identified in 8 patients at endoanal MRI and in no patients with EAUS [19]. In a study of 18 patients, three-dimensional (3D) EAUS and endoanal MRI showed no difference in the assessment of external anal sphincter atrophy, but there was a substantial difference in grading [20]. However, another study with 18 fecal-incontinent patients showed that correlation between EAUS and endoanal MRI for external anal sphincter thickness, length, and area was poor [21]. The decreased delineation of the external anal sphincter border in external sphincter atrophy probably impairs accurate evaluation.

Abnormal thinning (<2 mm) of the internal anal sphincter can be found in patients with idiopathic degeneration [22]. Atrophy of the internal anal sphincter is most easily appreciated at an axial image, and a cutoff of 2 mm thickness is used to identify internal sphincter atrophy in older individuals. Internal sphincter atrophy is nicely demonstrated at both endoanal MRI (Fig. 34.2) and EAUS.

34.6 MRI in the Management of Fecal-Incontinent Patients

The results of EAUS and endoanal MRI in the detection of external sphincter defects are comparable. The widespread experience and availability, and lower costs and time efficiency, favor EAUS as the first-choice technique for detecting external sphincter defects. Endoanal MRI can be used as an alternative. In experienced hands, external phased array MRI can replace endoanal MRI. This is a time-efficient alternative, which lacks the discomfort associated with the introduction of an endoanal device, a drawback of both endoanal MRI and EAUS.

The principal role of endoanal MRI is in demonstrating and grading external sphincter atrophy. This finding is a negative predictor of the outcome of anterior anal repair. With current knowledge, MRI is the preferred method to demonstrate external sphincter atrophy. Data on EAUS are sparse and conflicting. Therefore, in patients considered for anterior anal repair, MRI should be performed to identify individuals with external sphincter atrophy. The use of external phased array MRI is a valuable alternative in experienced hands.

Neither EAUS nor endoanal MRI play a role in selecting patients for pelvic floor rehabilitation. In a series of 250 fecal-incontinent patients, neither technique had substantial predictive value for the outcome of pelvic floor rehabilitation [23]. More research into this area is needed.

34.7 Conclusions

The evidence on the role of endoanal MRI in fecal incontinence is considerable but not extensive. Endoanal MRI can be used as an alternative to EAUS for detecting external sphincter defects. Current evidence indicates that endoanal MRI should be used in patients considered for anterior anal repair because of external sphincter atrophy identification. The role of MRI in other surgical treatment options is an obvious topic for future research. One can speculate that external sphincter atrophy at MRI could be an important finding for sacral neuromodulation. However, one study reports that sacral nerve stimulation can be effective in patients with fecal incontinence related to atrophy of the external anal sphincter, regardless of the severity of atrophy detected by MRI [24]. Technical developments in MRI, such as diffusion weighted imaging, diffusion tensor imaging, and fiber tracking [25], could be of value in patients with fecal incontinence.

Take-Home Messages

- In patients with fecal incontinence, MRI is well tolerated and comparable to EAUS.
- The widespread experience and availability, and lower costs and time efficiency, favor EAUS as the first-choice technique for detecting external sphincter defects.
- Endoanal and external coil MRI are both accurate in detecting external sphincter atrophy.

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