Fistula in ano is a common condition that often recurs despite seemingly adequate surgery, usually because of infection that was missed at surgery. It is now increasingly recognized that preoperative imaging can help identify infection that would have otherwise gone unidentified. In particular, magnetic resonance (MR) imaging findings have been shown to influence surgery and markedly diminish the chance of recurrence; thus, preoperative imaging will become increasingly routine in the future. In this article, the authors describe the pathogenesis, classification, and imaging of fistula in ano, with an emphasis on MR imaging. Most important, the authors describe how the radiologist is well placed to answer the surgical riddles that must be solved for treatment to be effective.

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Fistula in ano (anal fistula) is a common condition that has a tendency to recur despite seemingly adequate surgery. Recurrence is usually due to infection that has escaped surgical detection and has thus gone untreated. It is now increasingly recognized that preoperative imaging, notably magnetic resonance (MR) imaging, can help identify infected tracts and abscesses that would otherwise have been missed. Preoperative MR imaging findings have been shown to influence subsequent surgery and markedly diminish the chance of recurrent disease as a result. Because of this, preoperative imaging is likely to become increasingly routine in the future, especially in patients with recurrent disease.

This review will detail the pathogenesis of fistula in ano, explain how pathogenesis causes the different types of fistula encountered, and describe how these types can be imaged, with the emphasis on MR. Most important, we will describe how the radiologist is well placed to answer the surgical questions that must be solved for treatment to be effective.

Anatomy and Etiology

To fully understand the role of imaging with regard to fistula in ano, an appreciation of its etiology and how the various fistula types are defined by anatomic boundaries is mandatory.

The anal canal is essentially a cylindrical space predominantly surrounds the anus rather than the rectum. However, the two terms are interchangeable.

With regard to the lining of the anal canal, the proximal half is characterized by longitudinal mucosal folds, the anal columns of Morgagni (2). The distal aspect of each column is linked to its neighbor by a small semilunar fold (the anal valves), which in turn forms small pockets (the anal sinuses, or crypts of Morgagni). The distal undulating limit of these valves is the dentate line (pectinate) line, which also marks the most distal aspect of the anal transitional zone, a histologic junction between anal squamous epithelium and rectal columnar epithelium.

The dentate line lies approximately 2 cm proximal to the anal verge and is a crucial landmark in fistula in ano because the anal glands empty into the crypts that lie proximal to the valves. These glands were first linked to the genesis of fistula in ano by Chiari (3), who suggested that they were the source of infection. Their purpose is unclear, although they may help lubricate the anus by secreting mucus into the anal crypts. The origin of the anal glands within the surrounding tissues is variable. For example, they are present in the subepithelium and may be present in the internal sphincter, and approximately one- to two-thirds of these glands are deeply sited within the intersphincteric space (4) (Fig 1). Most authorities believe that it is infection of these intersphincteric glands that is the initiating event in fistula in ano, in a process known as the “cryptoglandular hypothesis” (5). Furthermore, lymphoid aggregates surround the anal glands, which may partly explain the increased incidence of anal fistula in Crohn disease (6,7).

It is believed that gland infection results in an intersphincteric abscess if the draining duct becomes blocked by infected debris. This abscess may resolve by means of spontaneous drainage into the anal canal or may progress to an acute anorectal abscess, which is a common acute surgical emergency and is familiar to all general and coloproctologic surgeons (8). Treatment generally consists of incision and drainage of the most fluctuant part of the abscess; however, this procedure does not pay due attention to the source of infection in the intersphincteric space, with the result that as many as 87% of patients with an acute abscess may subsequently develop a fistula (9). Acute anorectal abscess and fistula in ano are, therefore, generally believed to be acute and chronic manifestations, respectively, of the same disease. Because of this, the search for intersphincteric infection and an anal canal internal opening followed...
by treatment of these at the time of acute manifestation has been advocated in an attempt to reduce the incidence of subsequent fistula (10).

Fistula in ano develops when an intersphincteric infection is allowed to continue unabated. It has a prevalence of approximately 0.01% and predominantly affects young adults (11). Fistula in ano is commoner in men, who dominate in all published series, with a male-to-female ratio of approximately 2:1 (11). Patients most commonly present to a female patient, in whom the anal canal is the site of origin. Fistula in ano most commonly presents in young adults (11).

Fistula Classification

By definition, a fistula is an abnormal tract that connects two epithelial surfaces. The anatomic course of an anal fistula will be dictated by the location of the infected anal gland and the anatomic planes and boundaries that surround it. There will usually be an internal enteric opening in the anal canal at the level of the dentate line—that is, at the original site of the duct draining the infected gland. In most cases this is at the 6 o’clock position, because anal glands are more abundant posteriorly (radial positions around the anus are referenced with respect to a clock face, with 12 o’clock being directly anterior) (13). The fistula can reach the perianal skin by a variety of routes, some more tortuous than others, and by penetrating and involving the muscles of the anal sphincter and surrounding tissues to a variable degree. Fistulas may thus be classified according to the route taken by this “primary tract” that links the internal and external openings.

Furthermore, classification largely determines treatment. In 1934, Milligan and Morgan (14) stressed the importance of the “anorectal ring” (anatomically, the puborectalis muscle) and categorized fistulas as those that entered the anal canal above or below this structure, warning that postoperative incontinence was highly likely if high fistulas were surgically divided without due attention. This classification was subsequently modified and refined by other authors, but the most comprehensive and practical classification in use today is that of Parks et al (6), who carefully analyzed a consecutive series of 400 cases referred to the surgeons of St Mark’s Hospital, London, England. Parks et al found that they were able to assign all fistulas into one of four groups: intersphincteric, transsphincteric, suprasphincteric, and extrasphincteric (6). Of importance, most of these groupings could be explained in terms of the cryptoglandular hypothesis.

The path of least resistance for fester intersphincteric infection is straight down the intersphincteric space, which creates an intersphincteric fistula; this type of fistula composed 45% of cases in the series of Parks et al (6) (Fig 2). Of importance, this fistula does not penetrate the adjacent external sphincter, which forms a relative barrier to spread. However, some truculent fistulas can cross the external sphincter and reach the ischiorectal fossa by doing so (Fig 2). This results in a transsphincteric fistula, which composed 30% of cases in the series of Parks et al. Other fistulas may spread upward in the intersphincteric space and arch over the puborectalis muscle, where they must cross the levator plate to reach the perianal skin. This type, the suprasphincteric fistula (Fig 2), composed 20% of cases in the series of Parks et al.

Parks et al (6) also noted a fourth type of fistula in 5% of cases. This type was characterized by the surprising absence of intersphincteric infection. Instead, the fistula entered the rectum or anorectal junction directly (Fig 2). Parks et al termed these extrasphincteric fistulas. Clearly, infection of the anal glands cannot explain this type of fistula, and Parks et al stressed that primary rectal or pelvic disease (eg, diverticular disease, rectal Crohn disease, carcinoma) should be sought when this type was encountered. It should be noted that the Parks et al series inevitably suffered spectrum bias owing to the specialized nature of St Mark’s Hospital, a bias acknowledged by Parks himself, with the result that complex fistulas were almost certainly overrepresented. For example, Parks et al did not describe submucosal fistulas, which are
very superficial and do not involve the sphincter at all.

While most fistulas probably start as a simple single primary tract, unabated infection may result in ramifications that branch away from this. These secondary tracts are generally known as “extensions” (Fig 3). Extensions may be intersphincteric, ischioanal, or suprarectal (pararectal), and their morphology may suggest tracts or abscesses. Exactly when a tract becomes an abscess is not precisely defined, but both terms describe regions of infection. The ischioanal fossa is the commonest site for an extension (6), especially one that arises from the apex of a trans sphincteric fistula (A in Fig 3). Extensions also occur in the horizontal plane and are known as “horseshoes” if there is ramification each side of the plane and are known as “horseshoes” if there is ramification each side of the internal opening (6) (Fig 3). The anatomic description of the path taken by the primary fistula tract and the location of any associated extension forms its “classification.”

Assessment and Treatment

Treatment is usually straightforward and involves laying open the fistula by means of surgical incision, usually by cutting down onto a metal probe that has been inserted into the primary tract. Indeed, James Syme (in 1838) thought laying open a fistula to be straightforward and wondered why the procedure was performed in a theater with “all the pomp and circumstance of a great operation” (15). Unfortunately, he was mistaken; there are many traps waiting for the unwary. Inappropriate incision and injudicious exploration can all too easily convert a simple fistula into a surgical nightmare, with disastrous consequences for the patient. The primary objectives are to eradicate the tract and drain all associated sites of infection while simultaneously preserving anal continence.

It is the right balance between eradication of infection and preservation of function that is the art of fistula surgery. To achieve this, two surgical questions need to be answered preoperatively: (a) What is the relationship between the fistula and the anal sphincter (ie, can the tract be safely laid open with only a low risk of postoperative incontinence), and (b) are there any extensions from the primary tract that need to be treated to prevent recurrence, and, if so, where are they?

Surgeons have traditionally relied on examination of patients who have been administered a general anesthetic, a procedure referred to as examination under anesthesia (EUA), to answer these questions. At EUA, the surgeon attempts to classify the fistula by palpating it to determine its relationship to the sphincter. However, anesthesia and consequent loss of tone impair precise identification of underlying muscles. A metal probe is inserted into the external opening and is directed toward the dentate line to find the internal opening. This is also not as straightforward as it sounds. For example, the internal opening is frequently not obvious, and the surgeon may need to inject hydrogen peroxide into the external opening while inspecting the anal canal.

The height of the internal opening relative to the anal canal and sphincters is also crucial; the higher the opening, the more sphincter will be divided. Although Milligan and Morgan (14) realized the importance of the puborectalis muscle for continence as long ago as 1934—“Whereas, if this ring be cut, loss of control surely results”—they suggested that most of the remaining sphincter could be sacrificed (14). However, it is now generally accepted that functional disability can follow even minimal division of the sphincter. Perhaps most important, injudicious probing during EUA can create new secondary tracts very easily. For example, forceful probing in the roof of the ischioanal fossa can rupture through the levator plate, causing a suprarectal extension or even a rupture into the rectum, which would cause an extrasphincteric fistula (6,12).

Identification of extensions at EUA is central to curing the fistula. It is well recognized that missed extensions are the commonest cause of recurrence, which has reached 25% in some series (16). Extensions require specific treatment and inevitably necessitate more extensive surgery. For example, suprarectal extensions are particularly difficult both to diagnose (because they are high above the anal canal) and to treat (because the levator plate forms a barrier to drainage).

The net result is that it can be very difficult at EUA to classify the primary tract with confidence, and there is ample opportunity to make matters worse. Patients with recurrent disease are a particular case in point. Such patients are more likely to harbor missed disease but are also difficult to assess. Multiple failed operations are the rule rather than the exception, with the result that digital palpation frequently cannot help distinguish between scarring due to repeated surgery and induration due to an underlying extension. Furthermore, patients in this group are also more likely to have extensions that travel several centimeters away from the primary tract, frustratingly in almost any direction, which further hampers detection of the extensions. The more chronic the fistula, the more complicated the associated extensions tend to be. The inevitable result is that these patients become progressively more difficult to treat, with both patient and sur-

Figure 3

Illustration in coronal plane shows fistula extensions (secondary tracts): A = extension into roof of ischioanal fossa, arising from apex of a trans sphincteric fistula; B = suprarectal pararectal extension arising from apex of a trans sphincteric fistula, C = suprarectal extension originating from intersphincteric plane, D = intersphincteric horseshoe.
geon becoming ever more exasperated. The key to breaking this loop is accurate preoperative assessment.

**Imaging Fistula in Ano: Fistulography**

For many years radiologists have attempted to help answer the surgical questions posed above, with varying degrees of success. Contrast material–enhanced fistulography was the first modality used. In fistulography, the external opening is catheterized with a fine cannula, and a water-soluble contrast agent is injected gently to define the fistula tract (Fig 4).

Unfortunately, fistulography has two major drawbacks. First, extensions from the primary tract may fail to fill with contrast material if they are plugged with debris, are very remote, or there is excessive contrast material reflux from either the internal or external opening. Second, the sphincter muscles themselves are not directly imaged, which means that the relationship between any tract and the sphincter must be guessed. Furthermore, an inability to visualize the levator plate means that it can be difficult to decide whether an extension has a supra- or an infralevator location. Similarly, the exact level of the internal opening in the anal canal is often impossible to determine with sufficient accuracy to help the surgeon. The net result is that fistulographic findings are both difficult to interpret and unreliable.

Very little has been written on fistulography for fistula in ano, probably because the modality is so fraught with errors. Kuijpers and Schulpen (17) attempted to determine its value by retrospectively reviewing fistulographic images in 25 patients. They found that the internal opening and associated extensions were demonstrated and correctly interpreted in only four (16%) subjects. Moreover, false-positive diagnoses of rectal openings and supralevator extensions were made in three (12%) patients, which would have resulted in serious surgical errors if acted on. The authors concluded that fistulography was “inaccurate and unreliable,” although they admitted prior bias against the technique (17). In contrast, Weisman and co-workers (18) found fistulography to be more useful in that it provided helpful information in nearly half of the 27 subjects in their study.

It has been suggested that the prime reason why fistulography is generally unhelpful is that radiologists are not familiar with the concepts of fistula pathogenesis and anatomy and the relevant surgical questions (17). One of the most hazardous misinterpretations is to diagnose a direct rectal opening merely because there is contrast material in the rectal lumen; usually, the contrast agent has merely refluxed up from the internal anal opening. Such radiology reports only encourage the surgeon to look for nonexistent openings and extensions, which can result in iatrogenic secondary tracts.

**Imaging Fistula in Ano: CT**

Computed tomography (CT) may depict fistula in ano, especially if rectal and intravenous contrast material are used, and initial reports were encouraging (19–21). However, fistula depiction is not enough; fistulas must be classified correctly, and more recent and better data suggest that CT cannot be used for this purpose with sufficient accuracy. This is because the CT attenuation of the anal sphincter and pelvic floor is similar to that of the fistula itself, unless the latter contains air or contrast material. This is compounded by the inability to image in the surgically relevant coronal plane. Comparative studies are sparse: A study of 25 patients with 17 fistulas found that CT could be used to correctly classify only four fistulas, in contrast to the 14 correct classifications achieved with endosonography (22). Potentially, the disadvantages of CT might be overcome by using multi-detector row CT fistulography, which offers the possibility of isotropic voxels and multiplanar imaging, but results are awaited and the motivation to perform these studies is likely limited by the ready availability of MR imaging. It should be borne in mind that CT is frequently used to search for abscesses in the context of Crohn disease, and fistula in ano may be encountered at the time of examination. At present, however, accurate classification of these fistulas is best left to MR imaging or anal endosonography, with CT probably limited to the diagnosis of fistula-associated pelvic abscesses where other imaging is unavailable or cannot be tolerated.

**Imaging Fistula in Ano: Anal Endosonography**

Anal endosonography, developed by Clive Bartram, FRCP, FRCS, FRCR, was the first technique to directly depict the anal sphincter complex in detail (23). Simple modification of a rotating rectal endoscope by covering it with a nondeformable plastic cone allowed the transducer to be withdrawn through the anal canal itself, situating it very close to the target structures and thus providing images of high spatial resolution. The technique has attracted considerable attention because of its ability to demonstrate the presence and extent of anal sphincter disruption, notably after vaginal delivery (24). Anal endosonography has also been extensively used for the preoperative classification of fistula in ano.
The examination is simple, rapid, and well tolerated by patients. The patient lies in the left lateral position or in the prone position if female (25). The probe is gently inserted into the distal rectum and then withdrawn through the anal canal. The internal sphincter is visualized as a hypoechoic ring encircling the anal canal, whereas the external sphincter is of mixed echogenicity (Fig 5). The intersphincteric space and longitudinal muscle lie between these and are of mixed echogenicity and are easily identified by using modern 10-MHz transducers (26).

Endosonography is particularly well suited to identification of the internal opening, because this opening is usually positioned right at the probe surface. It is important to realize, however, that a tract extending up to the anal mucosal surface is rarely seen. Although a breach in the subepithelial layer of the anal canal is occasionally present, it is more common for the position of the internal opening to be revealed as a hypoechoic focus in the intersphincteric space that abuts the internal sphincter, often with a small corresponding defect in the internal sphincter (Fig 6). Because intersphincteric fistulas do not stray beyond the intersphincteric space, they are usually very well visualized at anal endosonography. Transsphincteric fistulas are revealed by tracts that cross the external sphincter to reach the ischioanal fossa (Fig 6). As would be expected, extensions are revealed as hypoechoic fluid collections (Fig 7).

It was initially hoped that anal endosonography would revolutionize preoperative fistula classification, a view supported by the results of early studies (27). However, subsequent work has been inconclusive. For example, some investigators (28,29) have found the technique to be useful, while others (30) have found it to be no better than digital rectal examination. Furthermore, in direct comparisons with MR imaging, anal endosonography has been variously found to be superior (31), equivalent (32,33), or inferior (34,35). Much of this discrepancy is probably related to operator expertise, since anal endosonography, similar to fistulography, is highly operator dependent.

However, there are undoubtedly several areas where anal endosonography has specific disadvantages. For example, insufficient penetration of the ultrasound beam beyond the external sphincter, especially with high-frequency transducers, limits the ability to resolve ischioanal and supraleval infections, with the result that extensions from the primary tract may be missed at endosonography. Also, anal endosonography cannot be used to reliably distinguish infection from fibrosis, because both have a hypoechoic appearance (30). This causes particular difficulties in patients with recurrent disease, since infected tracts and fibrotic scars are frequently combined. Attempts have been made to clarify the course of patent tracts by injecting hydrogen peroxide or sonography contrast agents into the external opening during examination (34,35). However, gas formed within the tract as a result may cause acoustic shadowing that mimics an extension. Indeed, this phenomenon can occur with any tract that contains air, leading, for example, to intersphincteric fistulas being inadvertently classified as transssphincteric (Fig 8).

Anal endosonography is also disadvantaged by the inability to image in the surgically important coronal plane, so that it may be very difficult to distinguish supra- from infralevator extensions (Fig 7). Some investigators (36) have attempted to overcome this disad-
vantage by employing a three-dimensional acquisition (Fig 9), but this technique remains relatively experimental.

There is no doubt that anal endosonography is a valuable technique in the right hands. A recent study (37) in which anal endosonography was compared with digital rectal evaluation and MR imaging in 108 primary tracts found that digital evaluation resulted in correct classification of 61% of fistulas; anal endosonography, 81%; and MR imaging, 90%. Anal endosonography was particularly adept with regard to the site of the internal opening, with correct prediction in 91% of cases compared with 97% for MR imaging (37). However, there is little doubt that MR imaging is a superior technique overall and is now also generally available. Given this, the major role of anal endosonography in fistula disease is probably in the assessment of the degree of sphincter disruption in patients who become anally incontinent after surgery for a fistula. Endosonography has high spatial resolution, so it also has a particular role in patients who potentially have a small intersphincteric abscess that might be difficult to resolve by using standard body- or surface-coil MR imaging.

**Imaging Fistula in Ano: MR Imaging**

In recent years, MR imaging has emerged as the leading contender for preoperative classification of fistula in ano. The ability of MR imaging to help not only accurately classify tracts but also identify disease that otherwise would have been missed has had a palpable effect on surgical treatment and, ultimately, patient outcome.

**Technique**

Magnetic field strength does not appear to be a critical factor for good results (38). Although higher field strength might be relevant for more subtle differentiation of sphincter anatomy and tracts, no definite diagnostic benefit has been demonstrated, to our knowledge.

Authors of initial reports (39–43) on MR imaging necessarily used the body coil; this was thought to be possibly due to lower spatial resolution. The introduction of external phased-array surface coils increased the signal-to-noise ratio and spatial resolution, to good effect (46,47), and these coils quickly became generally available.

The best spatial resolution is achieved by using a dedicated endoluminal anal coil (48), which may be combined with a surface coil to increase the field of view (49). It should be noted that these endoluminal coils are not the same as a rectal coil but are of smaller diameter and are designed to be placed in the anus. The receiver coil is generally housed in a plastic cover that allows placement across the anal canal (Fig 10). The external diameter generally ranges between 12 and 19 mm, although smaller coils have been used for pediatric examinations (50,51). Endoluminal coils are susceptible to motion artifact, but this can be reduced by means of careful patient preparation. For example, patients should be asked to try and relax the sphincter and pelvic floor as much as possible, and due attention should be paid to comfort, including support for the coil and patient with pads (50). Spasmolytics such as 20 mg of hyoscine butylbromide (Buscopan; Boehringer Ingelheim, Ingelheim, Germany) or 1 mg of glucagon administered intramuscularly may help to reduce motion-induced artifacts. (Hyoscine butylbromide is not licensed for use in the United States.)

The choice of coil depends on personal preference, availability, the patient group studied, and the clinical question in each patient. In a study of 10 patients with cryptoglandular fistula (45), an endoluminal coil was found to be superior to a surface coil; in a subsequent study of 30 patients (52), however, a body coil was found to be superior overall because the limited field of view inevitable with endoluminal imaging meant that distant extensions were missed, a phenomenon that is especially
frequent in patients with Crohn disease (53). In a third study (49), endoluminal and phased-array coils were compared in 20 patients, and the investigators found that while the endoluminal coil was superior for classification of the primary tract, extensions were better imaged by using the superior field of view of the external coil.

These results clearly suggest that a large field of view is necessary whenever extensions are suspected—for example, in patients with recurrent fistula or Crohn disease. The high spatial resolution of endoluminal coils makes them ideal for precise demonstration of the location and height of the internal opening, and they may have a special role for demonstrating ano- or rectovaginal fistulas, which are notoriously difficult to image (54). Endoluminal coils are also valuable when simultaneous information on the degree of sphincter disruption is needed, which may be the case in patients who have undergone previous surgery. Endoluminal coils are sometimes difficult to place owing to anal stenosis or local pain as a result of extensive infection. Halligan and Bartram (52) found that an endoluminal coil could not be placed in 17% of their patients, whereas Stoker and colleagues (50) failed to place the coil in only 3%, which may reflect differences in patient population since the coil used in both studies was identical.

When circumstances allow, it is likely that an optimal examination will be achieved by using a combination of both external and endoluminal coils. However, it should be borne in mind that accuracy with a body or external coil alone remains high (41–43, 47,49,52), and lack of an endoluminal coil alone is insufficient reason to avoid preoperative MR imaging of fistula in ano. Indeed, examination with a body or phased-array coil has become standard practice, not least because endoluminal coils specifically designed for anal imaging remain relatively unavailable.

**MR Sequences**

Various investigators have adopted different strategies with respect to the MR sequences used to image fistula in ano. All agree that anatomic precision is needed so that the course of the fistula with respect to adjacent structures can be judged accurately, and all use some method with which infection (usually pus) can be highlighted. These aims can be achieved by a variety of means. Many investigators use the rapid and convenient fast spin-echo T2-weighted sequence, which provides good contrast between hyperintense fluid in the tract and the hypointense fibrous wall of the fistula while simultaneously enabling good discrimination between the several layers of the anal sphincter (50,55). Others have used T1-weighted sequences, which must be combined with intravenous contrast material for the fistula to be highlighted (43). Fat-suppression techniques are widely used with both T2-weighted (56) and gadolinium-enhanced T1-weighted sequences (the latter may be especially valuable in patients with Crohn disease, to differentiate between fluid and inflammatory tissue that are both hyperintense on fat-suppressed T2-weighted and/or short tau inversion-recovery [STIR] images). Normal anorectal structures do not enhance substantially, except for the internal anal sphincter and blood vessels, including hemorrhoids. Investigators have also successfully employed STIR, a sequence that combines fat suppression with high conspicuity of active tracts (41,47,52). Other approaches have included saline instillation into the external opening in an attempt to increase tract conspicuity (57) or rectal contrast medium (58,59). However, such measures increase the complex-

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**Figure 11**: Correct orientation for MR imaging of anal canal. Sagittal T2-weighted scout image through patient’s midline is used to plan images that are truly transverse with respect to anal canal, as shown by white lines. Coronal imaging is then performed at 90° to the transverse plane.

**Figure 12**: Coronal (a) T2-weighted fast spin-echo (2500/70; echo train length, 16; field of view, 300 mm; matrix, 256 × 512; section thickness, 4 mm; gap, 0.4 mm) and (b) coronal STIR (4000/42, inversion time of 150 msec; echo train length, 16; matrix, 224 × 256; section thickness, 4 mm; gap 0.4 mm; two signals acquired) MR images acquired with external phased-array coil show complex transsphincteric fistula with tract (short straight arrows) in left ischioanal fossa that extends below ischial bone (/) toward the upper leg (not shown). At the ischial tuberosity, bone marrow edema (long straight arrow) is visible on b. Arrowhead = external opening, curved arrow = small abscess, AS = anal sphincter.
ity of the examination in the face of the already excellent results achieved with more standard procedures. Imaging protocols are detailed in the Table.

### Imaging Planes

It is central to success that imaging planes are correctly aligned with respect to the organ of interest, namely the anal canal. Because the anal canal is tilted forward from the vertical by approximately $45^\circ$, straight transverse and coronal images will fail to achieve this alignment because of marked partial volume effect. Oblique transverse and coronal planes oriented orthogonal and parallel, respectively, to the anal sphincter are therefore necessary and are most easily planned by using a midline sagittal image (Fig 11). It may be necessary to align supplementary examinations with the rectal axis in complex cases of an internal opening high in the rectum, but this is seldom needed.

It is important that the imaged volume extend several centimeters above the levators and include the whole presacral space, both of which are common sites for extensions. The entire perineum should also be included. On occasion, tracts may extend for several centimeters, even leaving the pelvis or reaching the legs, and any tract visible must be followed to its termination if

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### External Phased-Array 1.5-T MR Protocols for Imaging Perianal Fistula

<table>
<thead>
<tr>
<th>Sequence and Plane*</th>
<th>TR/TE¹</th>
<th>Echo Train Length</th>
<th>Field of View (mm)</th>
<th>Matrix</th>
<th>Section Thickness/Intersection Gap (mm)²</th>
</tr>
</thead>
<tbody>
<tr>
<td>T2-weighted fast spin echo without fat suppression</td>
<td>2500/70</td>
<td>10</td>
<td>300³</td>
<td>256 × 512</td>
<td>3/0.3</td>
</tr>
<tr>
<td>T2-weighted fast spin echo with fat suppression Transverse</td>
<td>2500/70</td>
<td>10</td>
<td>300³</td>
<td>256 × 512</td>
<td>3/0.3</td>
</tr>
<tr>
<td>T1-weighted fast spin echo with fat suppression Transverse*</td>
<td>600/minimal</td>
<td>3</td>
<td>450</td>
<td>256 × 256</td>
<td>4/0.4</td>
</tr>
</tbody>
</table>

Note.—Parameters are typical and were established with EchoSpeed imager (GE Healthcare, Milwaukee, Wis). Field of view should include rectum and perineum; at endoanal MR, volume should encompass entire sensitive region of coil. For all sequences, two signals are acquired and bandwidth is 20.83 kHz.

* Transverse and coronal planes are off axis, orthogonal and parallel, respectively, to anal canal.

¹ TR/TE = repetition time (msec)/echo time (msec).

³ For endoanal MR, transverse section thickness and gap are 2–3 mm and 0.2–0.3 mm, respectively.

⁴ For endoanal MR, field of view is 160 mm for coronal and sagittal planes and 100 mm for transverse plane.

Additional value of routine use of this contrast-enhanced sequence is not yet determined, but it may help differentiate inflammation from abscess.

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**Figure 13**

a. b. c.

Figure 13: Transsphincteric fistula in a man with Crohn disease. (a, b) Transverse T2-weighted fast spin-echo MR images (echo train length, 16; field of view, 300 mm; matrix 256 × 512; section thickness, 4 mm; gap, 0.4 mm; two signals acquired) obtained (a) without (2500/70) and (b) with (4000/85) fat saturation and (c) transverse fat-saturated contrast-enhanced T1-weighted fast spin-echo image (see Table for parameters) show two separate fistula tracts (straight and curved arrows) in left posterior ischioanal space, close to the anal sphincter (A). Both tracts show confluent high signal intensity centrally, which represents pus in the tract lumen. On a and b, the surrounding inflammatory tissue (arrowheads) is of low signal intensity (a), which increases with fat-saturation (b) and especially with contrast enhancement (c). Anterior tract (curved arrow) demonstrates more adjacent inflammation (arrowheads) than does posterior tract (straight arrow).
this has not been included on the standard image volume (Fig 12). The imaged volume should encompass the whole sensitive region of the coil when an endoanal receiver is used. The precise location of the primary tract (eg, ischioanal or intersphincteric) is usually most easily appreciated by using transverse images; the radial site of the internal opening is also well seen on images in this plane. Coronal images best depict the levator plate, which helps distinguish supra- from infralevator infection. The height of the internal opening may also be best appreciated on coronal images, with the caveat that the anal canal must be imaged along its entire craniocaudal extent.

The radial plane (as used for imaging menisci of the knee) is seldom used but seems attractive because it has the potential to depict fistulas along their full craniocaudal extent, something that is only achieved with standard coronal imaging when the fistula is at the 3- or 9-o’clock position. Instead of being obtained parallel to the anal canal, the image planes radiate from it like the spokes of a wheel (60). Little research has specifically addressed the benefits of various imaging planes, but in a study of 20 patients (60) investigators found that the combination of a transverse series and a longitudinal series (coronal, sagittal, radial, or a combination) provided all necessary information for successful interpretation.

Interpretation

The success of MR imaging for preoperative classification of fistula in ano is a direct result of the sensitivity of MR for tracts and abscesses combined with high anatomic precision and the ability to image in surgically relevant planes. Accurate preoperative classification is achieved by correctly relating the imaged fistula to the anal sphincter.

Primary Tract

Active tracts are filled with pus and granulation tissue and, thus, appear as hyperintense longitudinal structures on T2-weighted or STIR images (Fig 12). On contrast-enhanced T1-weighted images, active granulation tissue will enhance while fluid in the tract itself remains hypointense (Fig 13). Active tracts are often surrounded by hypointense fibrous walls (Fig 13), which can be relatively thick, especially in patients with recurrent disease and previous surgery. Occasionally, some hyperintensity in this fibrous area may be seen, probably reflecting edema. Hyperintensity may also extend beyond the tract and its fibrous sleeve, where it represents adjacent inflammation (Fig 13).

The external anal sphincter is clearly visualized by using MR imaging. It is relatively hypointense, and its lateral border contrasts against the fat in the ischioanal fossa, both on STIR (Fig 14) and especially on fast T2-weighted MR studies (Fig 13a). Thus, it is relatively easy to determine whether a fistula is contained by the external sphincter or has extended beyond it. If a fistula remains contained by the external sphincter throughout its course, then it is

Figure 14: Intersphincteric fistula in a male patient. Transverse STIR MR image (1500/15, field of view, 375 mm; matrix, 256 × 256; section thickness, 4 mm; gap, 1 mm; four signals acquired) shows that lateral margin of external sphincter (long arrow) contrasts against fat in the ischioanal fossa (+). Fistula (short arrow) is in the intersphincteric space posteriorly at 6 o’clock and is contained by the external sphincter. There is no tract in the ischioanal fossa.

Figure 15: Fistula classified as suprasphincteric on coronal STIR MR images (same parameters as for Fig 14) in a female patient. (a) Primary tracts in right (long arrow) and left (short arrow) ischioanal fossae are shown. (b) Image obtained just posterior to a shows that right-sided primary tract (white arrows) arches over puborectalis muscle (+) to reach a lower internal opening at the dentate line level (black arrow).
highly likely to be intersphincteric (Fig 14). In contrast, any evidence of a tract in the ischioanal fossa effectively excludes an intersphincteric fistula. However, transsphincteric, suprasphincteric, and extrasphincteric fistulas all share the common feature of a tract that lies beyond the confines of the external sphincter. While a transsphincteric fistula will be the commonest cause of a tract in the ischioanal fossa (Fig 13), differentiation between these three fistulas is only possible by locating the internal opening and determining the course between this and the primary tract.

Internal Opening

The exact location of the internal opening can be difficult to define, whatever the imaging modality used. Two questions need to be answered. What is the radial site of the internal opening, and what is its level? The vast majority of anal fistulas open into the anal canal at the level of the dentate line, commensurate with the cryptoglandular hypothesis of fistula pathogenesis. Furthermore, most fistulas also enter posteriorly, at the 6-o’clock position. Unfortunately, the dentate line cannot be identified as a discrete anatomic entity, even when endoanal receiver coils are used, but its general position can be estimated with sufficient precision for the imaging assessment to be worthwhile. The dentate line lies at approximately the mid–anal canal level. This is generally midway between the superior border of the puborectalis muscle and the most caudal extent of the subcutaneous external sphincter. These landmarks define the “surgical” anal canal (as distinct from the “anatomic” anal canal, which is shorter and is defined as the canal caudal to the anal valves). The dentate level is probably best appreciated on coronal views, which allow the craniocaudal extent of the puborectalis muscle and external sphincter to be appreciated; with experience, however, its location can be estimated with reasonable precision by using transverse views.

It should be noted that in some patients the puborectalis muscle is rather gracile, unlike the bulky muscle suggested in many anatomy texts, and it frequently and imperceptibly segues into the external sphincter, all of which hampers precise identification of the mid–anal canal level. Nevertheless, with experience it is possible to estimate the exact height of the internal opening with reasonable precision (47).

Any tract that penetrates the pelvic floor above the level of the puborectalis muscle is potentially a suprasphincteric or extrasphincteric fistula. The level of the internal opening distinguishes between these types of fistula; specifically, the internal opening is anal in suprasphincteric fistulas (Fig 15) and rectal in extrasphincteric fistulas (Fig 16).

Transsphincteric fistulas penetrate the external sphincter, a feature that can be easily appreciated on transverse (Fig 17) or coronal views. However, recent studies (61) in which MR imaging was used have revealed that a transsphincteric tract may cross the sphincter at a variety of angles. For example, it may 

![Figure 16](image1.png)

![Figure 17](image2.png)

![Figure 18](image3.png)
arch upward as it passes through the external sphincter and thus cross the muscle at a higher level than would be deduced merely by inspecting the level of the internal opening. This is important, because such tracts will require a greater degree of sphincter incision during fistulotomy, with a corresponding increase in the risk of postoperative incontinence. MR imaging in the coronal plane is best for estimates of the precise angulation of the tract with respect to the surrounding musculature (61).

The radial site of the internal opening is easy to identify if the fistula tract can be traced right to the anal mucosa (Fig 17). The radial site is reported with respect to a clock face, with 12 o’clock being directly anterior. However, like endosonography, it is frequently impossible to trace a tract right up to the anal mucosa, especially if an endoanal coil has not been used. In such cases, an intelligent deduction must be made as to where the internal opening is likely to be. This is best accomplished by looking for the area of maximal intersphincteric sepsis, since the internal opening is likely to lie very close to this (Fig 18). The intersphincteric space and longitudinal layer are often seen as a hypointense ring between the internal and external sphincters (Fig 18). The internal sphincter is hyperintense on both T2-weighted fast spin-echo and STIR images, especially if contrast material has been used (62).

Extensions

The major advantage of MR imaging is the facility with which it can demonstrate extensions associated with a primary tract. Morphologically, extensions frequently take the form of complex tract systems, regions of which have often become dilated to create an abscess (although a precise radiologic distinction between abscess and a large tract remains elusive). Extensions appear as hyperintense regions on T2-weighted and STIR images and enhance if intravenous contrast material is used. Again, collateral inflammation can be present to a variable extent.

The commonest type of extension is one that arises from the apex of a transsphincteric tract and extends into the roof of the ischioanal fossa (Figs 3, 19). The major benefit of MR imaging findings is that they can alert the surgeon to extensions that would otherwise be missed. For example, extensions may be several centimeters from the primary tract (Fig 20), which makes them difficult to detect during clinical examination or EUA. This is especially the case when extensions are contralateral to the primary tract (Fig 21). It is also important to search for suprarelevator extensions (Fig 22), since these are not only difficult to detect but pose specific problems with regard to treatment. Horseshoe extensions spread across both sides of the internal opening and are recognized on MR images by their unique configuration (Fig 23); horseshoe extensions may be intersphincteric, ischioanal, or suprareclator. Complex extensions are especially common in patients with recurrent fistula in ano (Fig 21) or in those who have Crohn disease (Fig 13).

Effect of Preoperative MR on Surgery and Outcome

Over the past few years, imaging, notably MR, has revolutionized the treatment of patients with fistula in ano. This is because MR can be used to classify fistulas preoperatively with high accuracy while also alerting the surgeon to disease that would otherwise have been missed. While there are reports of the technique dating from 1989 (40), it was not until the description by Lunniss and co-workers (41) that the true potential of MR imaging was fully appreciated. Lunniss et al imaged 16 patients with cryptoglandular fistula in ano and compared the MR classifications they obtained with those from subsequent EUA. MR imaging proved correct in 14 (88%) cases, which immediately suggested that it was the most accurate preoperative assessment yet available. However, the remaining two patients, in whom MR suggested disease but EUA yielded normal findings, re-presented some months later with disease at the site initially indicated on MR images. This led the authors to conclude that...
MR imaging “is the most accurate method for determining the presence and course of anal fistulae” (41). This work was rapidly confirmed by others working in the field and was subsequently elaborated on.

Spencer and colleagues (63) independently classified 37 patients into those with simple or those with complex fistulas on the basis of MR imaging and EUA and found that MR results were the better predictor of outcome, with positive and negative predictive values, respectively, of 73% and 87% for MR and 57% and 64% for EUA. These results clearly implied that MR imaging and outcome were closely related and again raised the possibility that preoperative MR could help identify features that cause postoperative recurrence.

Beets-Tan and colleagues (46) extended this hypothesis by investigating the therapeutic effect of preoperative MR imaging; the MR imaging findings in 56 patients were revealed to the surgeon after he or she had completed an initial EUA. MR imaging provided important additional information that precipitated further surgery in 12 (21%) of 56 patients, predominantly in those with recurrent fistula or Crohn disease (46).

Buchanan and co-workers (47) hypothesized that the therapeutic influence and, thus, beneficial effect of preoperative MR imaging would be greatest in patients with recurrent fistula, since these patients had the greatest chance of harboring occult infection, while such fistulas were also the most difficult to evaluate clinically. After an initial EUA, Buchanan et al revealed the findings of preoperative MR imaging to the surgeons for 71 patients with recurrent fistula and left any further surgery to the discretion of the operating surgeon. They found that postoperative recurrence was only 16% for surgeons who always acted if MR findings suggested that areas of infection had been missed, whereas recurrence was 57% for those surgeons who instead always chose to ignore imaging results (47).

Ever since the results of Lunniss et al (41) suggested that EUA might be an imperfect reference standard with which to judge MR imaging, comparative studies have been plagued by the lack of a genuine reference standard. It is now well recognized that surgical findings at EUA are often incorrect. In particular, there are frequent false-negatives. In a recent comparative study of endosonography, MR imaging, and EUA in 34 patients with fistula due to Crohn disease, Schwartz and co-workers (32) found that a combination of the results of at least two modalities was necessary to arrive at a correct classification. Indeed, it is well established that many false-negative surgical results will only reveal themselves during long-term clinical follow-up, and, at this point in time, comparative studies that ignore clinical outcome are likely to be seriously flawed.

Imaging for Differential Diagnosis

Not all cases of perianal sepsis are due to fistula in ano. For example, acne conglobata, hidradenitis suppurativa, pilonidal sinus, actinomycosis, tuberculosis, proctitis, human immunodeficiency virus, lymphoma, and anal and rectal carcinoma may all cause perianal infection. While
clinical examination results are often conclusive, this is not always the case, and imaging may help with the differential diagnosis. The cardinal feature of fistula in ano is intersphincteric infection, which is not generally found in other conditions. Whenever imaging suggests that infection is superficial rather than deep seated and that there is no sphincteric involvement, other conditions such as hidradenitis suppurativa should be considered (Fig 24). For example, authors of a recent study (65) of patients with pilonidal sinus and fistula in ano found that MR imaging could be used to reliably distinguish between the two on the basis of intersphincteric infection and an enteric opening.

The possibility of underlying Crohn disease should always be considered in patients who have a particularly complex fistula, especially if the history is relatively short. Indeed, a perianal fistula is the presenting condition in 5% of patients who have a particularly complex fistula, especially if the history is relatively short. Indeed, a perianal fistula is the presenting condition in 5% of patients (34), and 30%–40% of patients with Crohn disease will experience anal disease at some time (66–68). Specific scoring systems for perianal Crohn disease have been proposed, such as the Perianal Crohn’s Disease Activity Index (69) and a recently described system based solely on MR imaging findings (70). Small-bowel imaging may be used to search for Crohn disease when it is suspected, and the possibility of underlying pelvic disease should be considered in any patient with an extraspincteric fistula, whether thought due to Crohn disease or otherwise.

Which Patients Should Be Imaged?

While fistula in ano is simple to diagnose and simple to treat in most patients, many other patients will benefit from detailed and accurate preoperative investigation. Where there is easy access to MR imaging, it could be argued that all patients should undergo preoperative imaging. For example, it has been estimated that the therapeutic effect of MR imaging is 10% in patients presenting for the first time with a seemingly simple fistula (64). Where access to imaging is more restricted, however, the clinician and radiologist will need to select those patients who are most likely to benefit. Since there is now overwhelming evidence that MR imaging alters surgical therapy and improves clinical outcome in patients with recurrent disease, MR should be routine in such cases. Patients presenting for the first time with a fistula that appears complex at clinical examination should also be referred, as should patients with known Crohn disease, since the preponderance of complex fistulas is increased.

There are also surgical situations where imaging is likely to be particularly beneficial, even when the fistula itself is simple. For example, the anterior external sphincter is very short in women, and division of this sphincter during fistula incision is particularly associated with postoperative incontinence, even when the fistula itself is simple and has no extensions. Faced with such a dilemma, the surgeon may choose to pass a thread (seton) through the tract rather than incise the fistula to provide drainage. The patient can undergo postoperative imaging so that the potential extent of sphincter division can be assessed by visualizing the relationship of the seton to the external sphincter. A decision can then be made whether to progress with fistulotomy or to keep the seton in place for a few months, after which time the internal opening can be closed with a rectal mucosal advancement flap. A seton can also be placed at EUA when the surgeon is uncertain about the relationship between the tract and the sphincter; postoperative imaging can then be used to help answer this question. In patients who undergo novel therapies, such as use of fibrin glue, imaging may be necessary during instillation to be confident that the whole tract has been filled (71).

MR imaging is not restricted to surgical assessment. Infliximab, a chimeric monoclonal antibody to human tumor necrosis factor-α, currently has a prominent role for the medical treatment of Crohn disease, especially in patients with a chronic fistula (72). However, infliximab therapy is contraindicated if an abscess is present, and MR imaging may be used to search for this (70,73). Indeed, MR imaging may be used to monitor infliximab therapy, since it seems that fistulas may persist in the face of clinical findings that suggest remission (74). For example, investigations (70,73) of MR in patients whose external opening has closed have revealed that underlying infection can still be present, indicating a need for continued therapy. Further studies are needed to determine whether MR monitoring improves outcome.

Where MR imaging is unavailable or where competent interpretation of the images is not possible, then anal endosonography is a viable and useful alternative. While recent comparisons have shown that MR imaging outperforms anal endosonography in all respects, the latter is far superior to simple clinical examination, and its performance in some areas is very close to that of MR (37). Notably, anal endosonography is very adept at depicting the internal opening.

Conclusion

In those patients with fistula in ano who have a high likelihood of complex disease, the evidence that preoperative MR imaging influences the surgical approach and the extent of exploration
and improves the ultimate outcome is now overwhelming. We hope that this article will stimulate radiologists to provide this service to their surgeons in the expectation that this will reduce the incidence of recurrent fistula in ano and the misery that this causes.

References
STATE OF THE ART: IMAGING OF FISTULA IN ANO

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