Introduction

Many tests are available to investigate anorectal disorders, each only providing part of a patient's assessment, so results should be considered together and alongside the clinical picture derived from a careful history and physical examination.

Investigations provide information about structure alone, function alone, or both, and have been directed to five general areas of interest: faecal incontinence, constipation (including Hirschsprung's disease), anorectal sepsis, rectal prolapse (including solitary rectal ulcer syndrome) and anorectal malignancy.

Anatomy and physiology of the anal canal

The adult anal canal is approximately 4 cm long and begins as the rectum narrows, passing backwards between the levator ani muscles. There is in fact wide variation in length between the sexes, particularly anteriorly, and between individuals of the same sex. The canal has an upper limit at the pelvic floor and a lower limit at the anal opening. The proximal canal is lined by simple columnar epithelium, changing to stratified squamous epithelium lower in the canal via an intermediate transition zone just above the dentate line. Beneath the mucosa is the subepithelial tissue, composed of connective tissue and smooth muscle. This layer increases in thickness throughout life and forms the basis of the vascular cushions thought to aid continence.

Outside the subepithelial layer the caudal continuation of the circular smooth muscle of the rectum forms the internal anal sphincter, which terminates distally with a well-defined border at a variable distance from the anal verge. Continuous with the outer layer of the rectum, the longitudinal layer of the anal canal lies between the internal and external anal sphincters and forms the medial edge of the intersphincteric space. The longitudinal muscle comprises smooth muscle cells from the rectal wall, augmented with striated muscle from a variety of sources, including the levator ani, puborectalis and pubococcygeus muscles. Fibres from this layer traverse the external anal sphincter forming septa that insert into the skin of the lower anal canal and adjacent perineum as the corrugator cutis ani muscle.

The striated muscle of the external sphincter surrounds the longitudinal muscle and between these lies the intersphincteric space. The external sphincter is arranged as a tripartite structure, classically described by Holl and Thompson and later adopted by Gorsch and by Milligan and Morgan. In this system, the external sphincter is divided into deep, superficial and subcutaneous portions, with the deep and subcutaneous sphincter forming rings of muscle and, between them, the elliptical fibres of the superficial sphincter running anteriorly from the perineal body to the coccyx posteriorly. Some consider the external sphincter to be a single muscle contiguous with the puborectalis muscle, while others have adopted a two-part model. The latter proposes a deep anal sphincter and a superficial anal sphincter, corresponding to the puborectalis and deep external anal sphincter combined, as well as the fused superficial and subcutaneous sphincter of the tripartite model. Anal endosonography (AES) and magnetic resonance imaging (MRI) have not
resolved the dilemma, although most authors report a three-part sphincter where the puborectalis muscle is fused with the deep sphincter.\cite{1,2} The external anal sphincter is innervated by the pudendal nerve (S2–S4), which leaves the pelvis through the lower part of the greater sciatic notch, where it passes under the pyriformis muscle. It then crosses the ischial spine and sacrospinous ligament to enter the ischiorectal fossa through the lesser sciatic notch or foramen via the pudendal (or Alcock's) canal.

The pudendal nerve has two branches: the inferior rectal nerve, which supplies the external anal sphincter and sensation to the perianal skin; and the perineal nerve, which innervates the anterior perineal muscles together with the sphincter urethrae and forms the dorsal nerve of the clitoris (or penis). Although the puborectalis receives its main innervation from a direct branch of the fourth sacral nerve root, it may derive some innervation from the pudendal nerve.

The autonomic supply to the anal canal and pelvic floor comes from two sources. The fifth lumbar nerve root sends sympathetic fibres to the superior and inferior hypogastric plexuses, and the parasympathetic supply is from the second to fourth sacral nerve roots through the nervi erigentes. Fibres of both systems pass obliquely across the lateral surface of the lower rectum to reach the region of the perineal body.

The internal anal sphincter has an intrinsic nerve supply from the myenteric plexus together with an additional supply from both the sympathetic and parasympathetic nervous systems. Sympathetic nervous activity is thought to enhance and parasympathetic activity to reduce internal sphincter contraction. Relaxation of the internal anal sphincter may be mediated by non-adrenergic, non-cholinergic nerve activity via the neural transmitter nitric oxide. Anorectal physiological studies alone cannot separate the different structures of the anal canal; instead, they provide measurements of the resting and squeeze pressures along the canal. Between 60% and 85% of resting anal pressure can be attributed to the action of the internal anal sphincter.\cite{3} The external anal sphincter and the puborectalis muscle generate the maximal squeeze pressure.\cite{3} Symptoms of passive anal leakage (where the patient is unaware that episodes are happening) are attributed to internal sphincter dysfunction, whereas urge symptoms and frank incontinence of faeces are due to external sphincter problems.\cite{4}

Faecal continence is maintained by the complex interaction of many different variables. Stool must be delivered at a manageable rate from the colon into a compliant rectum of adequate volume. The consistency of this stool should be appropriate and accurately sensed by the sampling mechanism. Sphincters should be intact and able to contract adequately to produce pressures sufficient to prevent leakage of flatus, liquid and solid stool. For effective defecation there needs to be coordinated relaxation of the striated muscle components with an increase in intra-abdominal pressure to expel the rectal contents. The structure of the anorectal region should prevent herniation or prolapse of elements of the anal canal and rectum during defecation.

Because of the complex interplay between the factors involved in continence and faecal evacuation, a wide range of investigations is needed for full assessment. A defect in any one element of the system in isolation is unlikely to have great functional significance and so in most clinical situations there is more than one contributing factor.

### Rectoanal inhibitory reflex

Increasing rectal distension is associated with transient reflex relaxation of the internal anal sphincter and contraction of the external anal sphincter, known as the rectoanal inhibitory reflex (Fig. 1.1). The exact neurological pathway for this reflex is unknown, although it may be mediated via the myenteric plexus and stretch receptors in the pelvic floor. Patients with rectal hyposensitivity have higher thresholds for rectoanal inhibitory reflex; it is absent in patients with Hirschsprung's disease, progressive systemic sclerosis, Chagas' disease, and initially absent after a coloanal anastomosis, although it rapidly recovers.

The rectoanal inhibitory reflex may enable rectal contents to be sampled by the transition zone mucosa to allow discrimination between solid, liquid and flatus. The rate of recovery of sphincter tone after this relaxation differs between the proximal and distal canal, which may be important in maintaining continence.\cite{5}

Further studies investigating the role of the rectoanal inhibitory reflex in incontinent patients show that as rectal volume increases, greater sphincter relaxation is seen, whereas constipated patients have a greater recovery velocity of the resting anal pressure in the proximal anal canal. There is a longer recovery time back to resting pressure in patients with faecal incontinence.\cite{6}

### Manometry

A variety of different catheter systems can be used to measure anal pressure and it is important to note that measurements differ depending on which is employed. Systems include microballoons filled with air or water, microtransducers and water-perfused
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3 catheters. These may be hand-held or automated. Hand-held systems are withdrawn in a measured stepwise fashion with recordings made after each step (usually of 0.5–1.0-cm intervals); this is called a station pull-through. Automated withdrawal devices allow continuous data recording (vector manometry).

Water-perfused catheters use hydraulic capillary infusers to perfuse catheter channels, which are arranged either radially or obliquely staggered. Each catheter channel is then linked to a pressure transducer (Fig. 1.2). Infusion rates of perfusate (sterile water) vary between 0.25 and 0.5 mL/min per channel. Systems need to be free from air bubbles, which may lead to inaccurate recordings, and must avoid leakage of perfusate onto the perianal skin, which may lead to falsely high resting pressures due to reflex external sphincter action. Perfusion rates should remain constant, because faster rates are associated with higher resting pressures, while larger diameter catheters lead to greater recorded pressure.

Balloons may be used to overcome some of these problems and may be more representative of pressure generated within a hollow viscus than recordings using a perfusion system. They are not subject to the same problems as a perfusion system when canal pressures are radially asymmetrical. Balloons can be filled with either air or water. Over the range of balloon sizes used (diameter 2–10 mm), diameter appears to have less of an effect on the pressures recorded than it does with water-perfused catheter systems.

Microtransducers that can accurately measure canal pressure continue to be developed, but they are expensive and fragile.
High-resolution anal manometry uses the same catheters as standard manometry but updated software presents the information in a new way that may increase its clinical utility, especially when used to produce a three-dimensional picture of the anal canal. High-definition manometry uses closely spaced solid-state sensors simultaneously to measure circumferential pressures in the rectum and throughout the anal canal, so there is no need to perform a station pull-through manoeuvre.

Three-dimensional anal canal manometry (vector volume manometry) utilises a radially arranged catheter setting (commonly eight-channel) that is automatically withdrawn from the anal canal during rest and squeeze, and computer software that produces a three-dimensional reconstruction of the anal canal (Fig. 1.3).

Three-dimensional manometry is also possible with high definition anal canal manometry. These systems can assess radial asymmetry or vector symmetry index (i.e. how far the radial symmetry of the anal canal differs from a perfect circle, which has a radial asymmetry of 0% or vector symmetry index of 1). Sphincter defects are associated with symmetry indices of 0.6 or less.

Three-dimensional anal canal manometry may differentiate between idiopathic and traumatic faecal incontinence by showing global external sphincter weakness rather than a localised area of scarred sphincter indicated by an asymmetrical vectogram. Anal vector manometry has been extensively used to assess obstetric anal sphincter injury. Following caesarean section, no change in anal pressures is seen; however, after vaginal delivery a fall in rest and squeeze pressures occurs. The reduction in pressures has been shown to be greatest after a third- or fourth-degree tear confirmed on AES. Functional anal sphincter length and vector volumes have been shown to decrease both at rest and during contraction after obstetric anal sphincter injury.

Pressure changes in the anal canal can be measured in a number of ways and each method has been validated for its repeatability and reproducibility, although individual methods are not interchangeable. Although the correlation between measurements made using different systems and catheters is good, the absolute values are different, so when comparing the results of different studies, it is essential to consider the method used to obtain the pressure measurements.

Significant variation exists in the results of anorectal manometry in normal asymptomatic subjects. Men have higher mean resting and squeeze pressures. Pressures decline after the age of 60 years, changes most marked in women. These facts must be considered when selecting appropriate control subjects for clinical studies. Normal mean anal canal resting tone in healthy adults is 50–100 mmHg. Resting tone increases in a cranial to caudal direction along the canal such that the maximal resting pressure is found 5–20 mm from the anal verge. The high-pressure zone (the part of the anal canal where the resting pressure is >50% of the maximum resting or squeeze pressure) is similar at rest between men and women (20 mm in length) but longer in men than women when squeezing (31 mm vs 23 mm). In a normal individual the rise in pressure on maximal squeezing should be at least 50–100% of the resting pressure (usually 100–180 mmHg). Reflex contraction of the external sphincter should occur when the rectum is distended, on coughing, or with any rise in intra-abdominal pressure.

In the assessment of patients with faecal incontinence, both resting and maximal squeeze pressures are significantly lower in patients with incontinence than in matched controls, but there is considerable overlap between the pressures recorded in patients and controls.

Ambulatory manometry

The use of continuous ambulatory manometry to record rectal and anal canal pressures has provided...
information on the functioning of the sphincter mechanism in a more physiological situation. The generation of giant waves of pressure in the rectum or neorectum may relate to episodes of incontinence in patients after restorative proctocolectomy. Ambulatory manometry has also identified patients in whom episodes of internal sphincter relaxation are not accompanied by reflex external sphincter contraction, a finding that may prove useful in selecting patients likely to benefit from biofeedback treatment.

**Anal and rectal sensation**

The anal canal is rich in sensory receptors, including those for pain, temperature and movement, with the somatic sensation of the anal transitional mucosa being more sensitive than that of the perianal skin. In contrast, the rectum is relatively insensitive to pain, although crude sensation may be transmitted by the nervi erigentes of the parasympathetic nervous system.

A variety of methods have been used to measure anal sensation. Initial assessment of anal sensation used a stiff bristle to detect light touch in the anal canal, and hot and cold metal rods to detect temperature sensation. Thermal sensation has been assessed with water-perfused thermodes; normal subjects can detect a change in temperature of 0.92°C. The ability of the mucosa to detect a small electrical current can be assessed by the use of a double platinum electrode and a signal generator providing a square wave impulse at 5 Hz of 100 μs duration. The lowest recorded current of three readings at the point at which the subject feels a tingling or pricking sensation in the anal canal is noted as the sensation threshold. Normal electrical sensation for the most sensitive area of the anal canal (the transition zone) is 4 mA (2–7 mA). Rectal mucosal electrical sensation may also be measured using the same technique as that used for anal mucosal electrical sensation measurement, with slight modification of the stimulus (500 μs duration at a frequency of 10 Hz).

The sensation of rectal filling is measured by progressively inflating a balloon placed within the rectum or by intrarectal saline infusion. Normal perception of rectal filling occurs after inflation of 10–20 mL, the sensation of the urge to defecate occurs after 60 mL, and normally up to 230 mL is tolerated in total before discomfort occurs.

Temperature sensation may be vital in the discrimination of solid stool from liquid and flatus, and is reduced in patients with faecal incontinence. It is thought that this sensation is important in the sampling reflex, although this is brought into question by the fact that the sensitivity of the anal mucosa to temperature change is not great enough to detect the very slight temperature gradient between the rectum and anal canal.

Anal mucosal electrical sensation threshold increases with age and thickness of the subepithelial layer of the anal canal. Anal canal electrical sensation is reduced in idiopathic faecal incontinence, diabetic neuropathy, descending perineum syndrome and haemorrhoids. There are differing reports on whether there is any correlation between electrical sensation and measurement of motor function of the sphincters (pudendal terminal motor latency and single-fibre electromyography).

The sampling mechanism and maintenance of faecal continence are complex multifactorial processes, as seen by the fact that the application of local anaesthetic to the sensitive anal mucosa does not lead to incontinence and in some individuals actually improves continence.

**Rectal compliance**

The relation between changes in rectal volume and the associated pressure changes is termed compliance, which is calculated by dividing the change in volume by the change in pressure. Compliance is measured by inflating a rectal balloon with saline or air or by directly infusing saline at physiological temperature into the rectum. In the former method, the filling of the rectal balloon can be either incremental or continuous. When continuous inflation of the rectal balloon is used, the rate of inflation should be 70–240 mL/min. Mean rectal compliance is about 4–14 mL/cmH\textsubscript{2}O, with pressures of 18–90 cmH\textsubscript{2}O at the maximum tolerated volume. Reports on the reproducibility of the measurement of rectal compliance are varied and many have found great variation within the same subject; the most reproducible measurement is usually the maximum tolerated volume. The use of the barostat to measure rectal compliance has been shown to be reproducible at pressures of between 36 and 48 mmHg. The compliance of the rectum does not differ between men and women up to the age of 60 years, but after this age women have more compliant rectums. Compliance is reduced in Behçet’s disease and Crohn’s disease and after radiotherapy in a dose-related fashion. It is also reduced in irritable bowel syndrome.

✅ The clinical use of these measurements may be limited due to the large inter- and intra-subject variation in values and the wide normal range, reducing the discriminatory value of this technique as a clinical investigation.
The association between changes in rectal compliance and faecal incontinence is less clear. Some state that compliance is normal in incontinence whereas others have found a reduction in compliance associated with faecal incontinence, although changes in compliance may be secondary to the incontinence and not causative. Altered compliance may play a role in soiling and constipation associated with megarectum.

Pelvic floor descent

Parks et al. first described the association between excessive descent of the perineum and anorectal dysfunction, and subsequently it has been described in several conditions: faecal incontinence, severe constipation, solitary rectal ulcer syndrome, and anterior mucosal and full-thickness rectal prolapse. The presumption in all these conditions is that abnormal perineal descent, especially during straining, causes traction and damage to the pudendal and pelvic floor nerves, leading to progressive neuropathy and muscular atrophy. Irreversible pudendal nerve damage occurs after a stretch of 12% of its length, and often the descent of the perineum in these patients is of the order of 2 cm, which is estimated to cause pudendal nerve stretching of 20%.

Descent of the perineum was initially measured using the St Mark’s perineometer. The perineometer is placed on the ischial tuberosities and a movable Perspex cylinder is positioned on the perineal skin. The distance between the level of the perineum and the ischial tuberosities is measured at rest and during straining. Negative readings indicate that the plane of the perineum is above the tuberosities and a positive value indicates descent below this level. In normal asymptomatic adults, the plane of the perineum at rest should be level. In normal asymptomatic adults, the plane of the perineum is above the tuberosities and a positive value indicates descent below this plane. In patients with megarectum, the results of anorectal manometry do not correlate with changes in compliance and faecal incontinence, although the degree of incontinence and the results of anorectal manometry do not correlate with the extent of pelvic floor laxity.

Electrophysiology

Neurophysiological assessment of the anorectum includes assessment of the conduction of the pudendal and spinal nerves, and electromyography (EMG) of the sphincter.

Electromyography

Electromyographic traces can be recorded from the separate components of the sphincter complex, both at rest and during active contraction of the striated components. Initially, EMG was used to map sphincter defects before surgery, but AES is now so superior in its ability to map defects and is so much better tolerated by patients that EMG has largely become a research tool. Broadly, two techniques of EMG are used: concentric needle studies and single-fibre studies.

Concentric needle EMG records the activity of up to 30 muscle fibres from around the area of the needle both at rest and during voluntary squeeze. The amplitude of the signal recorded correlates with the maximal squeeze pressure, polyphasic long-duration action potentials indicating reinnervation subsequent to denervation injury. The main use of this technique has been in the confirmation and mapping of sphincter defects. Examination of puborectalis EMG may be more sensitive than cinedefecography in the detection of paradoxical puborectalis contraction in obstructed defecation, although paradoxical puborectalis contraction is also present in normal subjects.

The use of an anal plug or sponge can record global electrical activity from the anal sphincters. EMG amplitudes recorded in this way correlating with voluntary squeeze pressure. EMG performed using a needle has a smaller recording area (25 μm diameter) and the action potential from individual motor units is recorded. Denervated muscle fibres can regain innervation from branching of adjacent axons, leading to an increase in the number of muscle fibres supplied by a single axon.

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Degeneration. These changes predominantly affect the external anal sphincter but the puborectalis and levators are also affected to a lesser extent.

MFD correlates inversely with squeeze pressure and is increased in patients with excessive perineal descent. The correlation with direct assessment of the integrity of sphincter innervation (pudendal nerve terminal motor latency) is less clear.

**Pudendal nerve terminal motor latency**

Pudendal nerve conduction can be assessed by stimulating the nerve as it enters the ischio-rectal fossa at the ischial spine. This investigation only examines the fastest conducting fibres of the pudendal nerve and so can still be normal even in the presence of abnormal sphincter innervation. The normal value for pudendal nerve terminal motor latency (PNTML) is $2.0 \pm 0.5$ ms.

Prolongation of PNTML is associated with idiopathic faecal incontinence, rectal prolapse, solitary rectal ulcer syndrome, severe constipation and sphincter defects. Nerve latency is delayed with increasing age and is prolonged in 24% of all faecally incontinent patients and 31% of those presenting with constipation.

**Spinal motor latency**

Transcutaneous stimulation of the sacral motor nerve roots provides further information on the innervation of the pelvic floor. The motor response from stimulation at the level of the first and fourth lumbar vertebrae can be recorded using standard EMG needles inserted into the puborectalis and external sphincter. By comparing the latency times between the two levels, the latency of the motor component of the cauda equina can be assessed. Up to 23% of patients with idiopathic faecal incontinence have cauda equina delay.

**Defecography/evacuation proctography**

Defecography or evacuation proctography involves video fluoroscopy of the patient evacuating barium paste of stool consistency. Barium-soaked gauze may also be inserted into the vagina and barium paste may be applied to the perineum to aid in assessing the anorectal angle and perineal descent. Opacification of the small bowel with an orally ingested contrast medium or injection of contrast into the peritoneum (peritoneography) will reveal enteroceles in 18% of patients with pelvic floor weakness, with only half containing bowel. Defecography is a dynamic examination; it not only provides information on anorectal structural changes during defecation, but it also assesses function. While anatomical changes during evacuation (namely rectocele, enterocele, rectoanal intussusception, rectal prolapse and changes in anorectal angle) may be evident, the extent and duration of emptying is of more clinical significance.

During normal evacuation the anorectal angle increases because of relaxation of the puborectalis. Normal evacuation should be 90% complete (and 60% complete with a pouch). Rectoceles are significant if they are greater than 3 cm or require perianal/vaginal digitation to empty.

**Dynamic pelvic MRI**

Using a modified T2-weighted single-shot fast spinecho imaging sequence or a T2-weighted fast imaging with steady-state free precession MRI sequence, anorectal and pelvic floor motion can be imaged at 1.2- to 2-second intervals. During dynamic MRI, proctography provides pelvic images at rest and when the subject strains. This gives an overview of pelvic floor movement and organ prolapse, and rectal dynamics are assessed during evacuation after adding 150 mL of ultrasound gel to the rectum (Fig. 1.4). There are few differences in the detection of clinically relevant findings between supine MRI and seated MRI, except for detecting rectal intussusceptions, for which seated MRI is superior.

MRI defecography has been shown to alter the surgical approach in 67% of patients undergoing surgery for faecal incontinence. It has also been shown that inter-observer agreement for assessing anorectal motion by MRI proctography is better than with barium defecography.
Dynamic transperineal and three-dimensional pelvic floor ultrasound

Continued developments in diagnostic ultrasound imaging can contribute to the diagnostic work-up of female patients with obstructed defecation, rectal intussusception, rectal prolapse and rectocele. Pelvic floor ultrasound scanning has the advantage of being better tolerated and cheaper than the other imaging modalities, as well as correlating well with defecating proctography and MRI. Further studies are required to fully understand and validate pelvic floor ultrasound.

Scintigraphy

Scintigraphy using technetium-labelled sulphur colloid mixed with dilute vegum powder may also be used for defecography. The advantages of this technique are that a quantitative result is obtained and a lower dose of radiation is used. The study is not dynamic and does not correlate with patient symptoms or manometric assessment. Radioisotope testing may also be used to assess colonic transit time to diagnose idiopathic slow transit constipation. Colonic transit time is measured more easily by tracking the progress of ingested sets of radio-opaque markers with plain abdominal radiography. A standard protocol uses a single plain abdominal radiograph 5 days after commencing ingestion of the markers (usually different-shaped markers are taken daily over the first 3 days).

Imaging the rectum and anal sphincters

The indications for anorectal imaging may be divided into three broad clinical areas: sepsis and fistula disease, malignancy and faecal incontinence.

The available techniques include surface scanning techniques, namely computed tomography (CT) and body coil MRI, and endoanal imaging, namely anal endosonography (AES), with or without subsequent multiplanar (three-dimensional) reconstruction, and endocoil MRI (largely unavailable now).

Anal endosonography/endorectal ultrasound

Three-dimensional endoluminal ultrasound uses a double-crystal design with 6–16 MHz frequency range encased in a cylindrical transducer shaft. The transducer is then used with a specially designed rectosigmoidoscope and water-filled balloon covering the transducer. This allows rectal scanning without moving or replacing the probe. The ultrasonic anatomy has been described in detail by scanning dissected specimens and comprises alternating bands of reflection created by the interfaces between the different anatomical structures present. An alternating bright and dark pattern of rings is seen corresponding to the layers of the rectal wall.

To enable examination of the anal sphincters, the water-filled balloon is removed. The anal canal mucosa is generally not seen on AES; the subepithelial tissue is highly reflective and surrounded by the low reflection from the internal anal sphincter. The thickness of the internal sphincter increases with age: the normal width for a patient aged 55 years or younger is 2.4–2.7 mm, whereas in an older patient the normal range is 2.8–3.4 mm. As the width of the sphincter increases it becomes progressively more reflective and more indistinct; this may be due to a relative increase in the fibroelastic content of this muscle as a consequence of ageing. Both the external anal sphincter and the longitudinal muscle are of moderate reflectivity. The intersphincteric space often returns a bright reflection.

Another development is the use of volume rendering in three-dimensional AES, allowing the analysis of information inside a three-dimensional volume by digitally enhancing individual voxels. The volume-rendered image provides better visualisation performance when there are not large differences in the signal levels of pathological structures compared with surrounding tissues.
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MRI provides images with excellent tissue differentiation, although spatial resolution of the anal sphincters using a body coil receiver is poor. When an endoanal receiver coil is used, spatial resolution is vastly improved locally around the coil (within about 4 cm), enabling the acquisition of images of the anal sphincters with both excellent tissue differentiation and spatial resolution. Endocoils have either rectangular or saddle geometry and measure 6–10 cm in length and 7–12 mm in diameter. This increases to 17–19 mm after encasement in an acetal homopolymer (Delrin) former. The coil is inserted in the left lateral position and then secured with sandbags or with a purpose-built holder to avoid movement artefact. 50,52,53

On T2-weighted images, the external sphincter and longitudinal muscle return a relatively low signal. The internal sphincter returns a relatively high signal and enhances with gadolinium (an intravenous contrast agent used in MRI). The subepithelial tissue has a signal intensity value between that of the internal and external sphincters (Fig. 1.6).

Imaging in rectal cancer

CT has an accuracy of 89% in assessing rectal tumours with extensive spread beyond the serosal layer; however, when only cases of moderate tumour spread are assessed, the accuracy is much lower.
lower (55%). The accuracy of CT has been improved by the advent of multislice technique CT and further improvement is expected from modern scanners with up to 64 detector rows. CT is also used to assess metastatic disease involving the liver and lungs. The development of positron emission tomography (PET) combined with CT has improved the detection of recurrent rectal carcinoma. PET/CT can also yield additional pretreatment staging information in patients with low rectal cancer. EUS, by comparison, can correctly T-stage rectal cancers in 75–87% of cases, with a trend to over-stage in 22%. EUS is superior to CT and has a positive predictive value for tumour invasion beyond the muscularis propria of 98%. If a lymph node measures greater than 5 mm in diameter on EUS, there is a 45–70% chance that it is involved with tumour.

Body coil MRI has been used to assess the stage of rectal tumours and it would appear to give comparable results to EUS, with an accuracy of 88% at detecting transmural spread, 87% anal sphincter infiltration, and an accuracy of T-staging of 75% and a 94% accuracy in detecting circumferential resection margin involvement. A meta-analysis of 84 studies showed EUS to be slightly superior to MRI in assessing nodal status. Body coil MRI has the advantage over EUS in that it can be performed even in the presence of stenotic tumours. Furthermore, after radiotherapy EUS tends to over-stage tumours, leading to a marked reduction in its diagnostic accuracy, especially in the differentiation between T2 and T3 tumours. The other area where MRI is superior to EUS is in the assessment of recurrent tumours. The only advantage of EUS over MRI is the possibility of assessing T1 tumours that could be treated by transanal endoscopic microsurgery. The appearances of fibrosis after surgery and recurrent tumour in the pelvis are very similar using either EUS or CT, which makes assessment for recurrent disease very difficult. On MRI the signals from these two tissue types (especially on T2-weighted images) are quite different, allowing greater tissue differentiation. High resolution MRI has become the preferred imaging for the local staging of rectal cancer and helps guide surgery and identify the need for neoadjuvant treatment. PET/MRI is the newest clinical hybrid imaging modality and has the potential to provide comprehensive colorectal cancer staging in one examination.

EUS appears better at estimating the stage of T0, T1, T2 rectal tumours and nodal staging. However, the main determinant of local recurrence is circumferential resection margin and EUS is poor at assessing this, whereas MRI has been shown to be much more accurate.

Imaging in anal sepsis and anal fistulas

Both surface imaging and endoanal imaging have been employed in the assessment of perianal sepsis. CT is unsatisfactory for the assessment of fistulas because of the poor definition of tracks, which is largely due to volume averaging. MRI may be used to assess anal fistulas and has been shown to be accurate for the definition of the anatomy of anal sepsis, especially horseshoe collections and the anatomy of complex fistulas. Endosonography is also able to detect and assess sphincter damage caused by chronic sepsis.

Endosonography is less accurate in the assessment of suprasphincteric sepsis and it is often difficult to differentiate between supravalevator and infravelvator collections, leading to inaccuracy in up to 20% of cases. The internal opening on AES is identified by penetration of the internal anal sphincter by the track because of the lack of definition of the mucosa and is of limited value close to the anal margin. The diagnostic accuracy of AES is increased with the use of hydrogen peroxide injected into fistulous tracks to act as a contrast medium. The use of three-dimensional AES and volume rendering improves the accuracy of AES further. MRI has the most to offer in the assessment of perianal sepsis. Anal sepsis appears on MRI as areas of very high signal, which enhance with the administration of the intravenous contrast agent gadolinium. Definition is further increased with the use of STIR (short tau inversion recovery) sequences to suppress the signal returned by fat. The Association of Coloproctology of Great Britain and Ireland position statement states that imaging is mandatory with either MRI or AES for complex fistulas. For complex or recurrent fistulas or those with horseshoe extensions, then an MRI should be obtained to guide surgery.
Imaging in faecal incontinence

AES has revealed that many patients who were thought to have idiopathic faecal incontinence in fact have a surgically remediable sphincter defect. It has also been shown that a much higher proportion of women sustain sphincter damage during childbirth than is suspected by clinical assessment alone. While the true incidence of sphincter tears may be lower than initially thought, many women sustain important morphological changes to the sphincter following delivery. The ability of AES to diagnose and correctly assess the extent of external sphincter damage has been validated by comparison with EMG studies and findings at surgery. AES is superior in the differentiation between those patients with idiopathic faecal incontinence and those with a sphincter defect when compared with either simple manometric assessment or vector volume studies.

MRI is also used to assess patients with faecal incontinence and the diagnosis of sphincter defects using endocoil MRI has been validated with surgical confirmation of defect presence and extent. Endocoil MRI may be superior to AES in the detection and assessment of external sphincter defects because of better sphincter definition using MRI, although it is more important that the clinician is familiar with the imaging technique used.

MRI has multiplanar capability (i.e. axial, sagittal and coronal images can be acquired), whereas standard AES provides only axially oriented images. The acquisition of volume ultrasound data has overcome this problem, and using three-dimensional AES has led to a better understanding of sphincter injury. A direct correlation exists between the length of a defect and the arc of displacement of the two ends of the sphincter.
The use of endocoil MRI has shown that incontinence in the absence of a sphincter defect may be due to atrophy, where the sphincter has been replaced by fat and fibrous tissue. The presence of external anal sphincter atrophy on endocoil MRI has been associated with poor results from anterior sphincteroplasty.

Summary

A wide variety of physiological and morphological tests is available for the assessment of the anus and rectum. Although there is no clear correlation between manometric/neurophysiological testing and clinical symptomatology in patients with idiopathic faecal incontinence, there is considerable value in performing these tests before surgery to predict long-term outcome. Anorectal investigation has revealed a large group of parous women who have occult sphincter trauma that may have a clinical impact as the women get older.

Anorectal physiological assessment is essential as an objective measure in patients with faecal incontinence and for the diagnosis of Hirschsprung’s disease, and may help select those patients who will have acceptable function after coloanal anastomosis or an ileoanal pouch.

Endoanal imaging is becoming the gold standard in the preoperative determination of sphincter integrity and defines those patients most likely to benefit from surgical intervention. Endorectal imaging of early rectal tumours correlates well with histological assessment of tumour depth. MRI is the imaging modality of choice to assess the circumferential resection margin and is accurate for the diagnosis of recurrent tumour after previous resection.

In patients with primary evacuatory disorders, neurophysiological testing and defecography assist in the demonstration of unsuspected rectoanl intussusception or rectoceles in patients who may benefit from surgery and those who may be suitable candidates for biofeedback therapy.

Anorectal investigation continues to have a major role in clinical research and has helped outline the anatomy of the component parts of the sphincter complex as well as to define the physiology of both defecation and anal continence. The understanding of these processes is vital to the correct management of patients with anorectal disorders.

**Key points**

- Normal pelvic floor function relies on a complex interplay between various mechanisms.
- Sphincter function may be assessed using anal manometry and electrophysiology.
- Sphincter anatomy may be assessed using AES and MRI, the former being the standard for the diagnosis of sphincter trauma.
- Dynamic MRI evacuation proctography and dynamic pelvic floor scans are useful in the assessment of patients with evacuatory disorders.
- Pelvic MRI or three-dimensional AES may be used to assess anorectal sepsis and can predict recurrence of anal fistulas after surgery.
- MRI is the preferred modality for the staging of rectal cancer with more accurate circumferential resection margin prediction. Preoperative staging of early T1 rectal cancer is superior with EUS.

**Key references**


In this study 35% of patients with faecal incontinence had reduced resting pressure and 73% had reduced squeeze pressures, higher percentages than the control group. This study also found that volume and pressure thresholds for defecatory desire were lower in faecal incontinence patients.


McHugh and Diamant found that in faecally incontinent patients, 39% of women and 44% of men had normal resting and squeeze pressures, and 9% of asymptomatic normal individuals were unable to generate an appreciable pressure on maximal squeeze.

This meta-analysis of the accuracy of preoperative imaging included studies between 1985 and 2004. It showed that MRI was the only investigation accurate at predicting circumferential resection margin. EUS was slightly but not significantly superior at predicting nodal status.


A meta-analysis of 90 articles showed that for muscularis propria invasion, EUS and MRI had similar sensitivities but the specificity of EUS (86%) was significantly higher than that of MRI (69%). For perirectal tissue invasion, sensitivity of EUS (90%) was significantly higher than that of CT (79%) and MRI (82%). EUS was more accurate than CT and MRI at diagnosing perirectal tissue invasion and there was no difference in diagnosis of lymph node involvement.


This prospective trial of 104 patients with anal fistulas showed that AES with a high-frequency transducer is superior to digital examination but MRI is superior to AES.


This meta-analysis reviewed published papers for EAS and MRI between 1970 and 2010. The sensitivity of both techniques was good but the specificity was poor. Due to the significant variations between the studies, the authors suggested further work is required to advise on clinical use.