High Resolution Magnetic Resonance Imaging of the Anal Sphincter Using a Dedicated Endoanal Coil

Comparison of Magnetic Resonance Imaging with Surgical Findings

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PURPOSE: To obtain high resolution images of the anal sphincter and adjacent anorectum using an endoanal coil in patients with sepsis, trauma, and low rectal tumors and to compare imaging appearances with findings at time of surgery. PATIENTS AND METHODS: A cylindrical saddle geometry coil (diameter, 9 mm; length, 75 mm) was used to examine 30 patients (mean age, 53.6 years). Pathologies included perianal sepsis (10 patients), obstetric trauma (7 patients), and low rectal tumors (13 patients). Imaging was performed on an 0.5-T Picker Asset or 1.0-T Picker HPQ Vista (Picker International, Highland Heights, OH). T_1 and T_2 weighted and short inversion time inversion recovery transverse images and T_1 weighted coronal images were obtained. Intravenous gadopentetate dimeglumine (0.1 mmol/kg) was given to all patients with suspected infection and neoplasms. RESULTS: Abscesses and fistulas identified using magnetic resonance imaging (MRI) in patients with perianal sepsis were confirmed at surgery in all cases; site of fistulous internal opening into the anal canal was correctly identified in 80 percent of cases. Extent of sphincter tear was correctly assessed on endoanal MRI in all patients with obstetric trauma when compared with surgical findings. Tumor invasion of anal sphincter was seen in 38.5 percent of low rectal carcinomas. CONCLUSIONS: MRI with an endoanal coil provides detailed images of the site and extent of anal fistulas, sphincter tears, and local tumors and is of considerable value in preoperative assessment. [Key words: Anal sphincter; Endoanal coil; Magnetic resonance imaging]

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Disruption or inflammation of the anal sphincter caused by sepsis, trauma, or low rectal tumors are common problems currently imaged with anal endosonography,[1-4] although soft tissue contrast using this modality is low. Magnetic resonance imaging (MRI) provides superior soft tissue contrast, but the resolution of various muscle layers of the anal sphincter is poor when a whole body receiver coil is used.[5] Quality of magnetic resonance images may be improved by the use of a receiver coil placed in close proximity to the anal sphincter[6-8]; however, the value of this technique in detecting the exact site and extent of lesions has not been established. The purpose of this study was to evaluate this technique prospectively in assessment of anorectal pathology by comparing imaging appearances with findings at the time of surgery.

PATIENTS AND METHODS

A cylindrical saddle-geometry receiver coil mounted on an acetal homopolymer former 9 mm in diameter and 75 mm in length was used. Further details concerning this coil have been described elsewhere.[6, 9]

Thirty patients with a variety of pathology (14 male and 16 female; aged 25-94 (mean, 53.6) years) were studied. Nine were referred with perianal discharge and fistula-in-ano, 7 with obstetric trauma to the sphincter, and 13 with low rectal tumors. Clinical details are given in Tables 1, 2, and 3.

With patients in the lateral decubitus position, the coil (covered in a rubber sheath) was positioned within the anal canal across the sphincter. The patient was then turned supine and the coil immobilized with an external

Table 1.
Clinical, MRI, and Surgical Diagnoses of Patients with Anal Sepsis (n = 10; 7 Males, 3 Females)

No.	Age	Sex	Symptoms/Clinical Diagnosis	MRI Diagnosis	Surgical Findings
1	49	M	Anal discharge/perianal infection	Inter- and transsphincteric collection 7 OC fistula-in-ano	Inter- and transsphincteric collection 7 OC fistula-in-ano
2	63	M	Anal discharge/perianal Crohn's disease	Intersphincteric collection 6 OC fistula-in-ano	Intersphincteric collection 6 OC fistula-in-ano
3	34	M	Perianal Crohn's disease	Extrasphincteric collection 9–10 OC	Extrasphincteric collection 9–10 OC
4	38	M	Anal discharge	Intersphincteric collection 6 OC	Intersphincteric collection 6 OC
5	52	M	Anal discharge	Intersphincteric collection 6–7 OC	Intersphincteric collection 6 OC
6	45	M	Anal discharge	Intersphincteric collection 6 OC	Intersphincteric collection 6 OC
7	33	F	Anal discharge	Intersphincteric collection 11–1 OC	Intersphincteric collection 12 OC fistula-in-ano
8	39	M	Perianal discharge	Extrasphincteric collection anteriorly	Perianal abscess at base of scrotum
9	34	F	Anal discharge	Intersphincteric collection 12–2 OC fistula-in-ano	Intersphincteric collection 12–2 OC fistula-in-ano
10	25	F	Anal discharge	Right-sided inter, trans, and extrasphincteric collection	Extensive right-sided sphincter sepsis

OC = o'clock; MRI = magnetic resonance imaging.

Table 2.
Clinical, MRI, and Surgical Diagnoses of Patients with Sphincter Trauma (n = 7; 7 Females)

No.	Age	Sex	Symptoms/Clinical Diagnosis	MRI Diagnosis	Surgical Findings
11	26	F	Fecal soiling, obstetric trauma	External sphincter 10–2 OC	Disrupted sphincter 9–2 OC
12	33	F	Fecal soiling, obstetric trauma	External and internal sphincter disrupted anteriorly	Disrupted sphincter anteriorly
13	30	F	Fecal incontinence, obstetric trauma	Marked hemiatrophy of all muscle components on left	Marked sphincter hemiatrophy on left
14	42	F	Fecal incontinence and vaginal discharge, obstetric trauma	Anterior defect 12 OC	Anterior rectovaginal fistula
15	44	F	Rectovaginal discharge, obstetric trauma	Internal sphincter with streaky high signal likely defect 12 OC	Disrupted external sphincter, anterior rectovaginal fistula
16	60	F	Fecal incontinence, obstetric trauma	Anterior external sphincter defect 9–3 OC	Disrupted external sphincter 9–3 OC
17	68	F	Fecal soiling, obstetric trauma	Disrupted internal sphincter 10–2 OC	Disrupted internal sphincter anteriorly

OC = o'clock; MRI = magnetic resonance imaging.

clamp. Imaging was done on a 0.5-T Picker Asset in 21 cases and on a 1.0-T Picker HPQ Vista in 9 cases using T_1 weighted spin-echo (SE; 720-820/20 (repetition time (TR)/ echo time (TE) msec), T_2 weighted spin-echo (SE 2500/80 (TR/TE) msec), fast spin-echo (FSE 4500/96 (TR/pseudo TE) msec), and short TI (inversion time)

Table 3.
Clinical, MRI, and Surgical Diagnoses in Patients with Low Rectal Neoplasms (n = 13; 7 Males, 6 Females)

No.	Age	Sex	Symptoms/Clinical Diagnosis	MRI Diagnosis	Surgical Findings
18	64	M	Anal pain	Lobulated tumor anteriorly	Low anterior tumor
19	68	M	Rectal bleeding, previous carcinoma rectum	Rectal tumor, no anal invasion	Circumferential rectal tumor
20	94	F	Rectal bleeding, tumor	Low rectal tumor, possible anal invasion	Anterior wall low rectal tumor
21	75	F	Rectal mucus discharge	Anterior rectal tumor, anal invasion 1–2 OC	Villous adenoma anteriorly at 4 cm
22	63	M	Rectal bleeding, tumor	Rectal tumor, no anal invasion	Rectal tumor
23	52	M	Rectal bleeding, tumor	Rectal tumor, no anal invasion	Anterior rectal tumor, prostatic invasion only
24	86	F	Change in bowel habit	Rectal tumor posteriorly, no anal invasion	Posterior wall low tumor
25	67	F	Rectal bleeding, palpable tumor	Low tumor, anterior anal invasion	Low anterior tumor
26	67	M	Rectal bleeding	Well-defined polypoid mass on left	Focal rectal prolapse
27	74	M	Rectal bleeding, change in bowel habit, previous anterior resection, and radiotherapy	Thickened anastomosis, radiotherapy changes	No recurrent tumor
28	76	F	Rectal bleeding	Polypoid rectal mass, no anal invasion	Tumor at 6 cm, no anal invasion
29	65	F	Rectal bleeding and mucus discharge	Lobulated mass involving sphincter 12–2 OC	Tumor at 6 cm, anal invasion
30	47	M	Previous anterior resection, stenosis of anastomosis	Mass-like thickening of anterior rectal wall, sphincter involved	Recurrent low rectal tumor, fixed pelvis

OC = o'clock; MRI = magnetic resonance imaging.

inversion recovery (STIR; 2500/30/107 (TR/TE/TI) msec) sequences. Transverse 3 mm contiguous slices were obtained with a 192 × 256 matrix, two to four signal averages, and a 12 cm field of view. All patients with suspected anal sepsis and rectal tumors received intravenous contrast agent (0.1 mmol/kg body weight of gadopentetate dimeglumine and also had postcontrast T_1 weighted (SE 720-820/20 (TR/TE) msec) scans. All 30 patients underwent surgery; 10 with suspected sepsis had fistulas laid open and collections drained, 7 with sphincter trauma had sphincter repair, and all 13 with rectal tumors had examination under anesthesia, and 7 subsequently had anterior resection.

Data Analysis

Images were analyzed preoperatively by two radiologists in conference for lesion detection and characterization without knowledge of surgical findings. Site and extent of all fistulous lesions were documented according to the Parks classification.[10] At subsequent surgery, the operating surgeon who was unaware of the scan findings recorded his assessment of the fistulas in a similar fashion. Presence, site, and extent of lesions were then compared.

Similarly, site and extent of tears within the sphincter and distance from anal verge was recorded on MRI and at surgery. A similar system was used to score the site and extent of tumors of the anorectum.

RESULTS

Anal Sepsis

All ten patients with perianal discharge who underwent surgery were confirmed as having sphincteric

abscesses (*i.e.*, a collection within some portion of the sphincter complex). MRI correctly identified all of these. Of these, one was transsphincteric, six were intersphincteric, two were extrasphincteric, and one involved all compartments. Two were in patients with perianal Crohn's disease. Abscesses had a short T_1 or appeared isointense on T_1 weighted spin-echo images (Fig. 1). On the T_2 weighted and STIR sequences, abscesses were highlighted in all cases. On administration of intravenous gadopentetate dimeglumine, five of these patients showed enhancement within the abscess (Fig. 2). Supralevator sepsis was not seen in any of our cases.

Fistulous connection with the anal canal was ap-

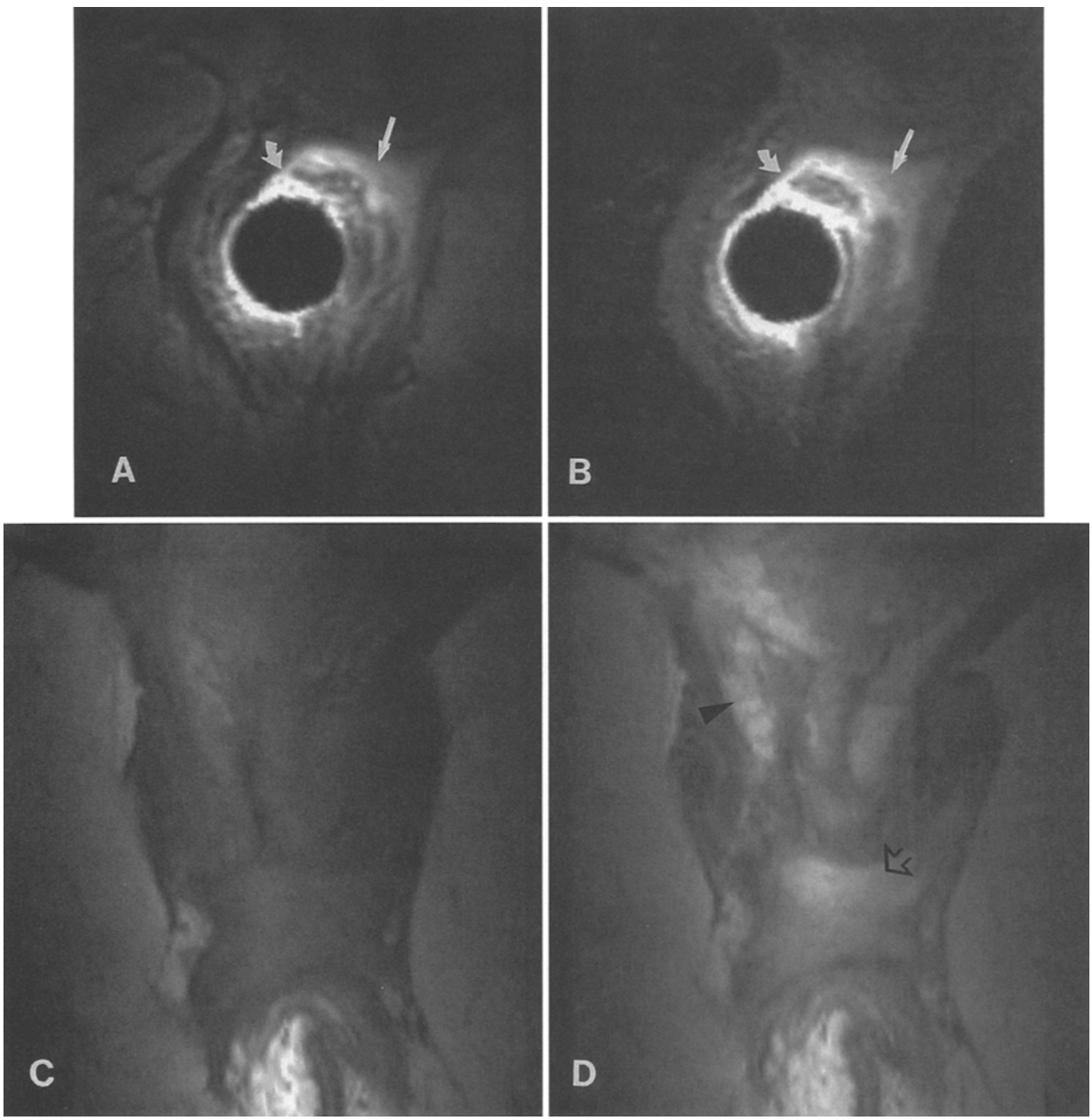

Figure 1. Perianal sepsis and fistula-in-ano in a 34-year-old female. Transverse T_2 weighted spin-echo (2500/80 (TR/TE)) (A) and STIR (2500/30/107 (TR/TE/TI)) (B) through the mid part of the anal sphincter and coronal T_1 weighted spin-echo (720/20 (TR/TE)) before (C) and after (D) administration of intravenous contrast. High signal is seen within the intersphincteric layer between 12 and 3 o'clock (arrow) in A and B. There is also involvement of the external sphincter. A fistulous connection with the anal canal is demonstrated at 12 o'clock (curved arrow). This region enhances after intravenous contrast in D (open arrow). Enhancement in normal vaginal mucosa (arrowhead) is noted incidentally.

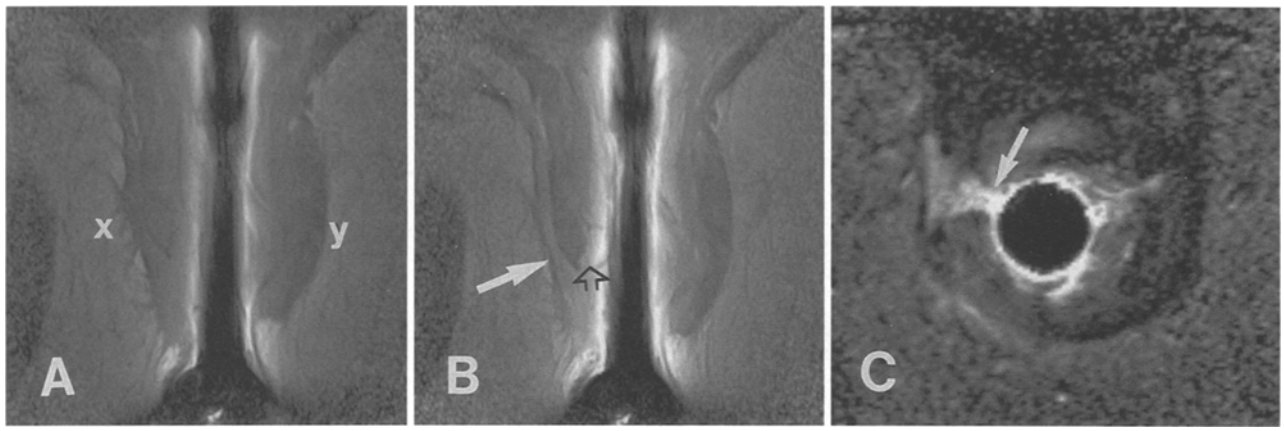

Figure 2. Extensive perianal sepsis in a 25-year-old female. Coronal T_1 weighted spin-echo (720/20 (TR/TE)) before (A) and after (B) administration of intravenous contrast. There is enhancement in an extrasphincteric collection on the right (large arrow) that extends superiorly up to the levators ani and medially through all muscle layers. Extensive involvement of the internal sphincter is noted (open arrow). A T_2 weighted (2500/80 (TR/TE)) transverse image (C) at the level x-y 2 cm from the anal verge shows that the abscess communicates with the anal canal on the right laterally (small arrow).

parent in four cases (Fig. 1). MRI findings were confirmed at surgery in each case. Position and course of the track in relation to the anal verge could be documented from coronal and sagittal images. One patient (Patient 7) had a fistula-in-ano at surgery not identified on MRI.

There was concordance between MRI and surgery for the presence of abscesses in 100 percent, presence and site of the track in 80 percent (4 of 5), and for position of internal opening in 80 percent (4 of 5). Sensitivity of MRI for identifying anal sepsis using surgical findings as the gold standard was 100 percent. Follow-up at a median of six months has not shown a recurrence of perianal sepsis in any of these patients.

Tears

In the seven patients who underwent surgical repair of the sphincter, MRI correctly diagnosed site and extent of the tear in all cases. In addition, in two patients with obstetric trauma who had rectovaginal fistulas, there were long T_2 regions anteriorly. In one case of obstetric trauma one year previously, marked hemiatrophy of all sphincter components on the left was noted with muscles replaced by fat (Fig. 3).

Accuracy of MRI for detecting the presence of a sphincter tear was 100 percent, and concordance between MRI and surgery for delineating site and extent of a tear was 100 percent. Defects were seen mainly in the external sphincter in five cases: two of five in the superficial and three of five in the deep muscle components. In the remaining two patients (28.6 percent), tears also involved the internal sphincter and were immediately recognized because of the profound loss of high signal intensity normally seen in this homogeneous muscle ring (Fig. 4).

Tumors

Thirteen patients with low carcinoma of the rectum were examined. Irregular lobulated masses of high signal representing tumor invasion of the sphincter were noted in five patients (Fig. 5). In one case, the tumor was heterogeneous with low signal foci on T_2 weighted and STIR imaging. MRI characteristics corresponded with biopsy findings of a malignant melanoma of the rectum.

No invasion of the anal sphincter with tumor was seen in the other eight cases (Table 3). Seven of these subsequently had anterior resection when the lack of anal invasion was confirmed. In the remaining case, the "tumor" was clearly demonstrated using the endoanal coil as a well-defined polypoid "mass" 3 cm above the levators ani with clear definition of the rectal musculature (Fig. 6). On subsequent review of the histology, it became apparent that the appearances were consistent with a focal rectal prolapse.

DISCUSSION

This study clearly documents the high overall sensitivity of endoanal MRI in detection of anal sphincter pathology when compared with a surgical gold standard.

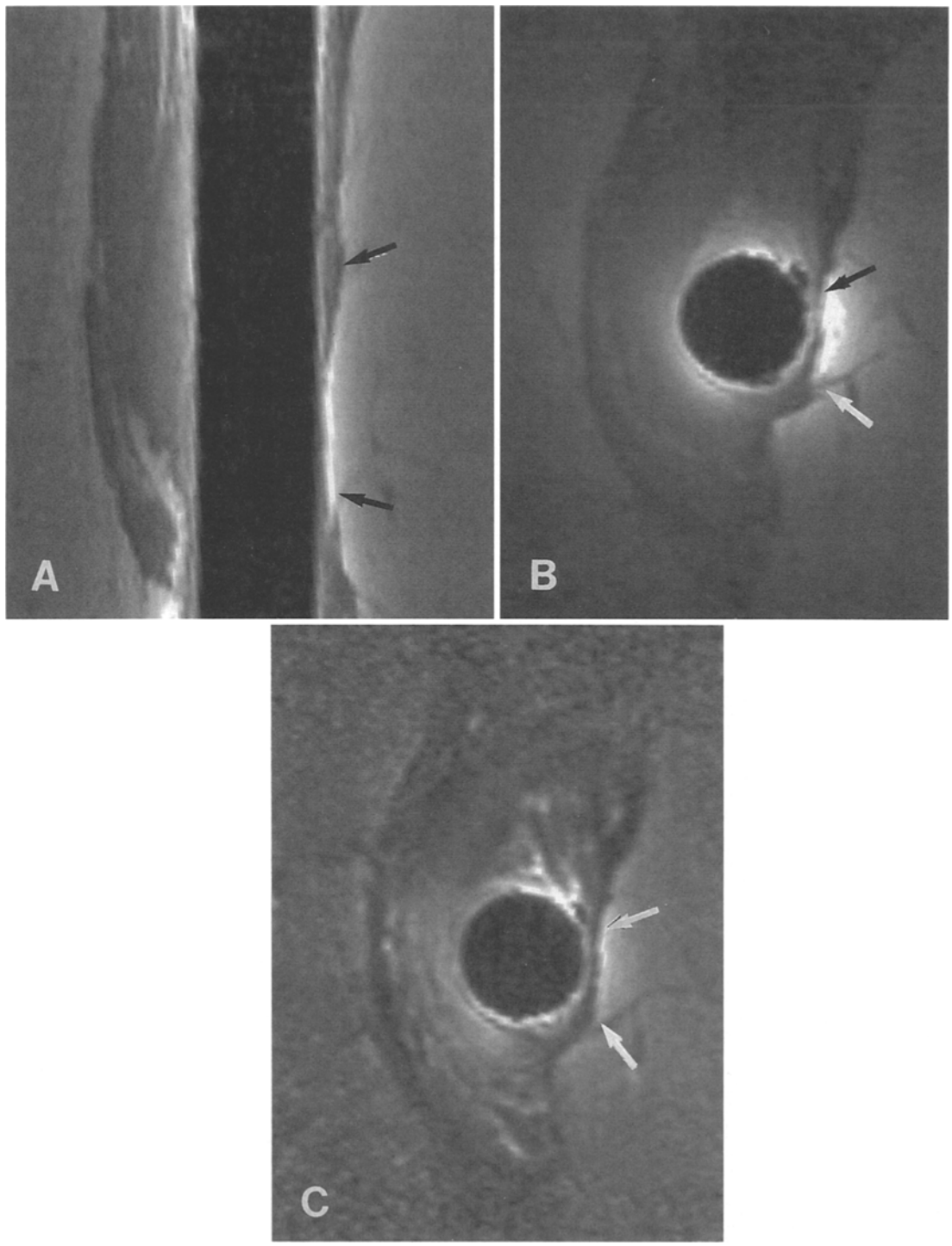

Figure 3. Sphincter disruption in a 30-year-old female. Coronal (A) and transverse (B) T_1 weighted spin-echo (720/20 (TR/TE)) and transverse T_2 weighted spin-echo (2500/80 (TR/TE) image (C) through the mid anal sphincter. There is marked hemiatrophy of all muscle layers of the sphincter on the left (arrows) following obstetric trauma 18 months previously.

Anal Sepsis

The change in T_1 and T_2 associated with infection produced high soft tissue contrast in keeping with expectations from imaging elsewhere in the body. This enabled abscesses and fistulous tracks to be demonstrated. Although previous studies have demonstrated the efficacy of MRI in demonstrating fistulas[11, 12] and changes in Crohn's disease[13] using a con-

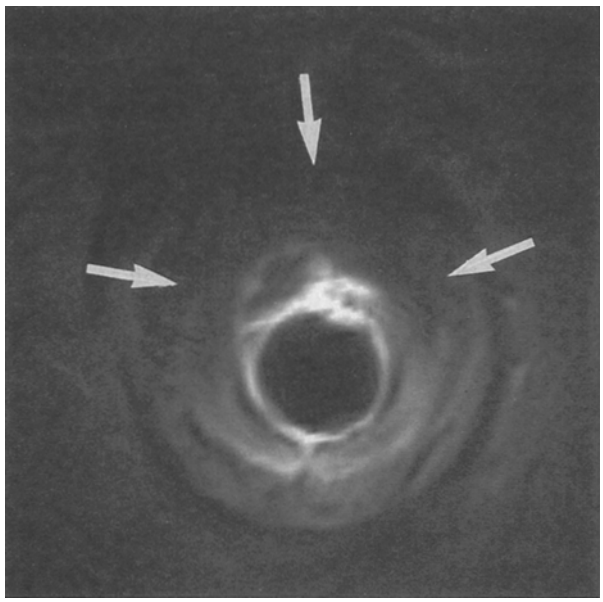

Figure 4. Internal sphincter disruption in a 68-year-old female. Transverse T_2 weighted spin-echo (2500/80 (TR/TE) through the mid anal sphincter. Complete loss of the normal high signal intensity of the internal sphincter is seen anteriorly between 10 and 2 o'clock (arrows).

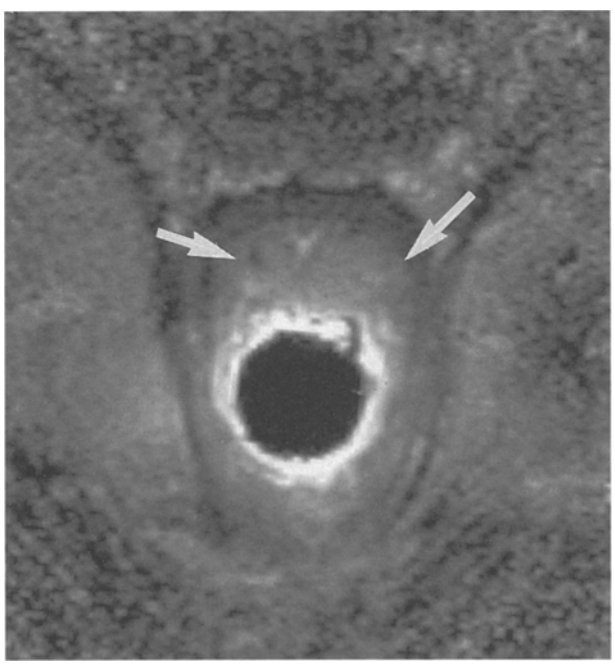

Figure 5. Low rectal tumor with anal invasion in a 67-year-old female. Transverse T_2 weighted spin-echo (2500/80 (TR/TE) image through the mid part of the anal sphincter. A lobulated tumor is seen within the anterior part of the internal sphincter (arrows).

ventional body coil, the excellent image quality provided by an internal coil is likely to result in further improvement. Contrast enhancement was seen in and

Figure 6. Focal rectal prolapse simulating a polypoid tumor with no anal invasion in a 60-year-old male. Coronal T_1 weighted spin-echo (720/20 (TR/TE)) image through the anal sphincter. A well-defined pedunculated "mass" is seen continuous with the rectal wall several centimeters above the levators ani (arrow).

around infective lesions and must be distinguished from normal enhancement. Established scar had a low signal on both T_1 and T_2 weighted images and was seen in close relation to normal sphincter and surrounding fat. Changes associated with hypertrophy and atrophy were also readily shown.

In a large unselected consecutive series of 793 patients,[14] the frequency of fistula type was found to be superficial in 16 percent, intersphincteric in 54 percent, transsphincteric in 21 percent, suprasphincteric in 3 percent, extrasphincteric in 3 percent, and multiple in 3 percent. The majority of fistula are, therefore, uncomplicated. Contrast fistulography,[15-18] anal endosonography,[19-22] computed tomography,[23, 24] and MRI using whole body coil[25] have all been used in preoperative assessment of anal fistulas. Results of contrast fistulography are variable with poor assessment of the internal openings and extensions.[18] Also, this technique is invasive and can disseminate infection.[26] Even in good hands, anal endosonography has been shown to be no better for diagnosis than digital examination under anesthesia.[20] Imaging the anal sphincter with computed tomography is unsatisfactory with poor demonstration of fistulas on axial im-

ages. Sensitivity of MRI using the body coil can be as high as 89 percent,[25] but demonstration of site of internal opening and differentiation of various muscle layers and fat planes between them is not always possible. Use of an endoanal coil allows high resolution images of anal musculature and perianal fat to be obtained so detailed evaluation of these areas is possible and a high accuracy for detecting fistulous tracks and abscesses can be achieved.

MRI also offers a multiplanar imaging facility so use of coronal and sagittal images in addition to the axial plane is available to assess the full extent of fistulas. Coronal images give the relationship of fistula to the levator ani, and anterior and posterior extension can be demonstrated on sagittal images.

STIR images were most useful for highlighting fistulous tracks and fluid collections. T_1 weighted contrast-enhanced scans served to confirm information available on STIR and were particularly useful if abscess was several centimeters away from the mucosa when the signal-to-noise drop-off with distance from the coil combined with the lower signal-to-noise of the STIR sequence made it difficult to define these lesions on STIR.

Tears

Use of T_2 weighted sequences provides tissue contrast between lower signal external sphincter and homogeneous higher signal of the circular internal sphincter,[27] but differentiation of the exact extent of the tear is not possible using body coil imaging. Any disruption of fibers can be clearly identified with high resolution scans using the endoanal coil. In particular, loss of normal homogeneous high signal intensity internal sphincter is easily recognized.

Tumors

The multiplanar facility of MRI allows clear delineation of tumor extent and invasion, particularly in relation to the levator floor. Exact distance from each of the components of the external sphincter and extent of internal sphincter involvement can be accurately assessed before surgical planning. Furthermore, manipulation of tissue contrast with the use of T_2 weighted sequences allows visualization of tumor invasion and breach of the muscular coat of the anorectum. However, with the length of coil used, detailed visualization of the musculature of the sphincter up to 2 cm above the levator ani only is obtained. To assess the full extent of low rectal neoplasms, a receiver coil placed within the rectum would be necessary. Such a coil used on its own or in conjunction with an external coil as part of an array would provide the best means of staging rectal tumors preoperatively using MRI.

CONCLUSION

Magnetic resonance imaging using a dedicated endoanal coil provides excellent visualization of abscesses and fistulas within and around the anal sphincter. It also gives an accurate assessment of the site and extent of tears and delineates the position of tumors involving the sphincter mechanism. Such information is valuable in preoperative assessment and surgical planning.

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