Electrophysiologic Assessments in Pudendal and Sacral Motor Nerves After Ileal J-Pouch-Anal Anastomosis for Patients with Ulcerative Colitis and Adenomatosis Coli

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PURPOSE: To clarify neurologic function with respect to external anal sphincter and puborectalis muscles after J configuration ileal J-pouch-anal anastomosis for patients with ulcerative colitis and adenomatosis coli, we examined the terminal motor latency in the pudendal and sacral motor nerve (S2-4). METHODS: Latency of the response in the external anal sphincter muscle following digitally directed transrectal pudendal nerve stimulation (PNTML) and in the puborectalis muscle following transcutaneous magnetic stimulation of the cauda equina at the levels S2-4 (SMNLTSS) were measured in 12 patients with ileal J-pouch-anal anastomosis; they were divided into a group with continence (7 cases) and a group with soiling (5 cases). Results were compared with data obtained from 12 patients before operation and 15 controls. RESULTS: Conduction delay of PNTML and SMNLTSS in patients with soiling was longest, followed by delay in those without any soiling, then delay in patients before operation, and then controls. In addition, significant differences were also noted between conduction delay of PNTML in controls and those who are incontinent and experience soiling ($P < 0.05$ and $P < 0.01$, respectively), and there were significant differences also noted between conduction delay of PNTML in patients before operation and those who are incontinent and experiencing soiling ($P < 0.05$ and $P < 0.01$, respectively). Conduction delay of PNTML and SMNLTSS were found in patients before operation rather than in controls. No significant differences were noted between conduction delay of PNTML and SMNLTSS in patients before operation and controls. Significant differences were also noted between conduction delay of PNTML and SMNLTSS in patients who are incontinent and experiencing soiling ($P < 0.01$, respectively). CONCLUSION: These findings support the hypothesis that soiling after this procedure may be partially caused by damage to pudendal and sacral motor nerves (S2-4). [Key words: Ileal J-pouch-anal anastomosis; Latency; Pudendal nerve; Sacral motor nerve; Anorectal function]

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Ulcerative colitis (UC) and adenomatosis coli (AC) is a disease of the mucosa of the colon and rectum; these diseases are cured, and risk of malignant transformation is eliminated if the colon and rectum are removed completely.[1, 2] In the past, definitive treatment required total proctectomy and a permanent ileostomy. Recently, restorative proctocolectomy with ileoanal reservoir has been a significant development in the surgical treatment of UC and AC.[2–6] Introduction of ileal J-pouch-anal anastomosis procedure revolutionized surgical management of UC and AC in the early 1980s.[3, 7, 8] Functional results have been acceptable, and patients satisfaction has been very high because patients are free from a stoma and lead near-normal lives.[1, 3, 7–13] During the past ten years, there has been much study of the function of the anorectum in patients with ileoanal anastomosis using anorectal manometry.[7–13] Anorectal manometry has now become a standard clinical test for assessment of internal and external sphincter muscles. Manometry is a technique used for recording pressure change within the bowel lumen caused by contractions of the gut wall itself. In contrast, much less is known about assessment of neurologic functions in regard to external anal sphincter and puborectalis muscle. To clarify neurologic function with respect to external and anal sphincters and puborectalis muscles after J configuration ileal pouch-anal anastomosis for patients with UC and AC, we examined the terminal motor latency in the pudendal and sacral motor nerve (S2–4).

MATERIALS AND METHODS

A total of 12 consecutive patients with UC (8 cases) and AC (4 cases) were included in this study, all of whom were completely continent before undergoing total colectomy with mucosal proctectomy and an ileal J-pouch-anal anastomosis using short cuff 7 cm from the dental line. There were eight men and four women, aged between 14 and 56 (mean, 39.2) years. Median follow-up time after closure of defunctional ileostomy was 53.9 (range, 20–106) months. All patients had an uneventful postoperative course without any complications; however, at the time of this study, five (UC, 4 cases; AC, 1 case) were experiencing occasional soiling indicated by minor leakage of mucus, one to five days per week. This study was performed in all patients before and after operation. Patients after operation were divided into two groups, depending on whether some soiling was experienced. As a control, 15 healthy volunteers (8 men and 7 women) aged between 27 and 69 (mean, 49) years were also examined. None of these healthy controls had any disturbances in bowel function at the time of this study.

Digitally Directed Pudendal Nerve Terminal Motor Latency

The terminal motor latency in the pudendal nerves (PNTML) can be used to assess function in distal parts of innervations of external anal sphincter muscles. Latency of the evoked muscle action responses in the external anal sphincter muscles were recorded after stimulation of bilateral pudendal nerves in the pelvis. This was accomplished by using a finger-mounted array of recording and stimulating electrodes. Thus, two stimulating electrodes were mounted at the tip, with the cathode arranged distally, and two recording electrodes were mounted side by side at the base to pick up the response in external anal sphincter muscles (Fig. 1). Stimulation of pudendal nerves was achieved in both sides of the pelvis by directing the finger covered with the sack in the rectum toward the ischial spine. Onset of this stimulus was used to trigger the oscilloscope (Universal Dual-Beam VC-9, Nihonkoden, Tokyo, Japan). Square wave stimuli of 0.1-ms duration and about 10 V (Electronic Stimulator SEN 7203, Nihonkoden, Tokyo, Japan), but always supramaximal, were used to find the shortest latency, measured from onset of the stimulus to onset of the response in the external anal sphincter muscle, which was felt through the examiner's finger covered with the sack (Isolator SS 104J, Signal Processor 7T18, Sanei-Nihonkoden, Tokyo, Japan).

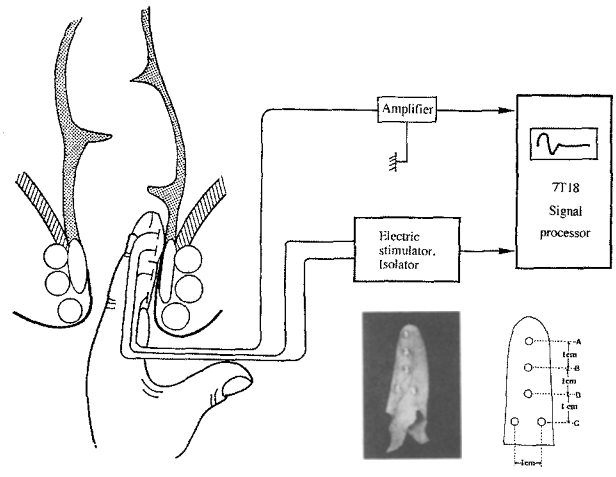

Figure 1. Measurement of terminal motor latency in pudendal nerves. Latency of evoked muscle action responses in external anal sphincter muscle is recorded after stimulation of pudendal nerves in pelvis. A = stimulating electrode (anode); B = stimulating electrode (cathode); C = recording electrodes; D = ground electrode.

Sacral Motor Nerve Latency After Transcutaneous Spinal Stimulation (SMNLTSS)

Nerves innervating the puborectalis muscle can be excited transcutaneously by stimulating the spinal column overlying the cauda equina, thus allowing measurement of the motor latency to this muscle. The patient was placed in the left lateral position, and a separate ground electrode was connected from the upper thigh to the preamplifier of the electromyography apparatus (Isolator SS 104J, 7T18 Signal Processor, Sanei-Nihonkoden, Tokyo, Japan). Stimulus was applied from a magnetic stimulator (Magstim-Model 200, Nihonkoden, Tokyo, Japan) consisting of a flat coil with an outer diameter of 9 cm, placed in the area overlying S2–4. A large, brief pulse of current (peak value, 4,000 A after 110 μs) was then passed from a high-voltage capacitor discharge system through the coil. The puborectalis muscle response was recorded with a glove-mounted electrode array. This consisted of two metal plates mounted 1 cm apart on the tip of the gloved index finger. The finger bearing this device was inserted into the rectum so that the electrode array was in contact with the puborectalis muscle on the right and left side. Stimulation at S2–4 sacral levels has been proved to activate the sacral nerve root of the cauda equina (Fig. 2).

Statistical Analysis

All data are expressed as mean ± standard deviation. Statistical analysis was performed with nonpara-

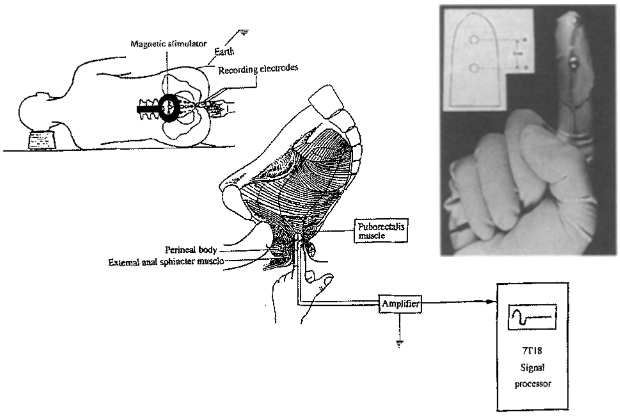

Figure 2. Measurement of sacral motor nerve latency after transcutaneous spinal stimulation. Latency of evoked muscle action responses in puborectalis muscles is recorded after stimulation of sacral motor nerve roots of the cauda equina. A and B = recording electrodes.

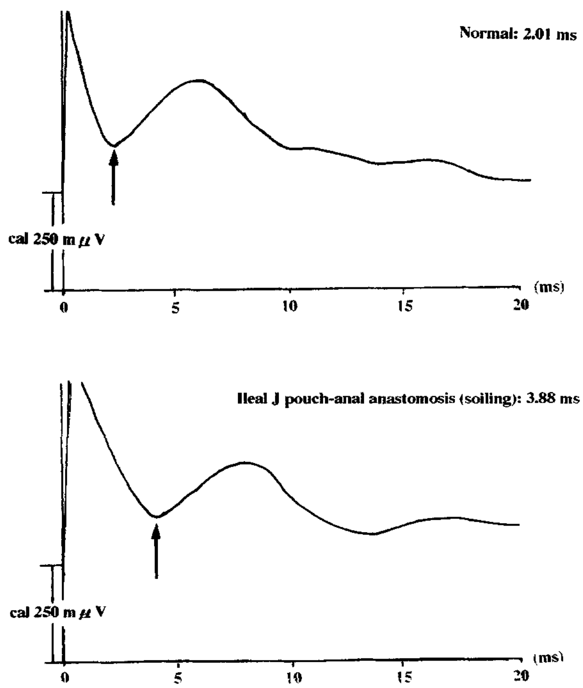

Figure 3. A typical pudendal nerve terminal motor latency of a control (upper side) and an ileal J-pouch-anal anastomosis patient with soiling (lower side).

metric statistical significance testing and Wilcoxon's rank-sum test. A P value of less than 0.05 was regarded as significant.

RESULTS

Pudendal Nerve Terminal Motor Latency

Figure 3 illustrates a typical PNTML of 1 of 15 controls and 5 ileal J-pouch-anal anastomosis patients who experienced soiling. Mean PNTML of controls was 1.91 ± 0.38 ms in the left side and 1.92 ± 0.35 ms in the right side. Mean PNTML of patients before operation was 1.96 ± 0.36 ms in the left side and 1.98 ± 0.42 ms in the right side. Mean PNTML of the seven patients who were experiencing no soiling was 2.31 ± 0.41 ms in the left side and 2.36 ± 0.35 ms in the right side, whereas mean PNTML of five patients with some degree of soiling was 4.01 ± 0.94 ms in the left side and 3.95 ± 0.86 ms in the right side. Conduction delay in the patients with some soiling was the longest, followed by those without any soiling, then controls (Fig. 4). Moreover, significant differences in PNTML were noted between controls and both patients with and without soiling ($P < 0.01$ and $P < 0.05$, respectively), between patients before operation and both patients with and without soiling ($P < 0.01$ and $P < 0.05$, respectively), and between patients with soiling and those without ($P < 0.01$). Conduction delays of PNTML were found on patients before operation rather than controls. No significant differences were found in conduction delay between patients before operation and controls. These results suggest that damage to the pudendal nerves may well be the cause of soiling that was seen after ileal J-pouch-anal anastomosis.

Sacral Motor Nerve Latency After Transcutaneous Spinal Stimulation (SMNLTSS)

Figure 5 illustrates a typical SMNLTSS of 1 of 15 controls and 5 ileal J-pouch-anal anastomosis patients with soiling. Mean SMNLTSS of controls was 3.65 ±

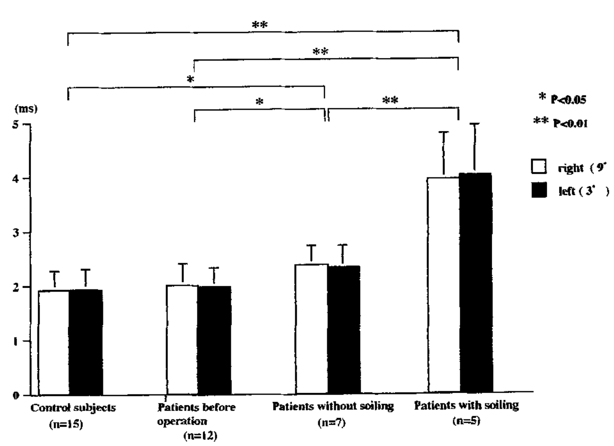

Figure 4. Pudendal nerve terminal motor latency. Conduction delay of pudendal nerve terminal motor latency in patients who experience soiling was significantly longer than it was in patients who had no soiling, before operation, or controls.

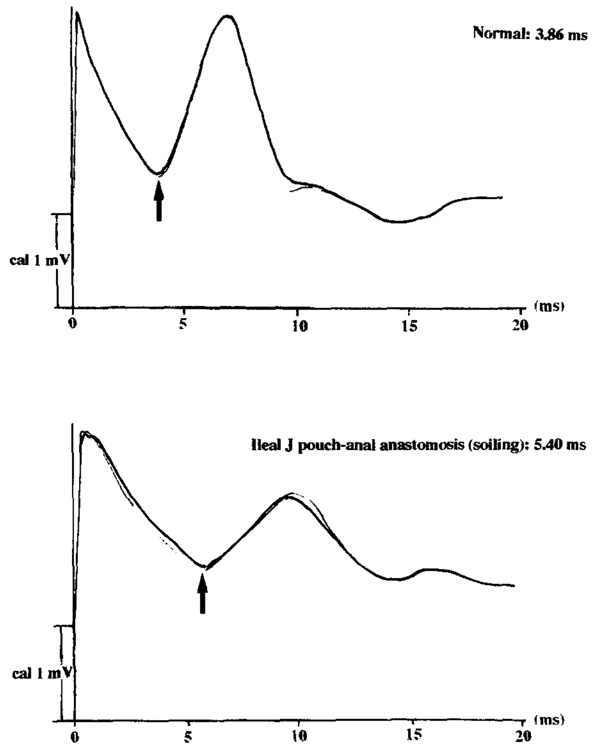

Figure 5. A typical sacral motor nerve terminal latency of a control (upper side) and an ileal J-pouch-anal anastomosis patient with soiling (lower side).

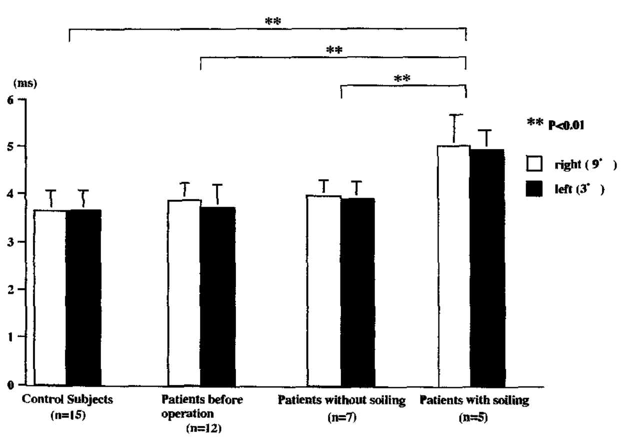

Figure 6. Sacral motor nerve latency after transcutaneous spinal stimulation. Conduction delay of sacral motor nerve terminal latency in patients who experienced soiling was significantly longer than it was in patients without soiling, before operation, or controls.

0.43 ms in the left side and 3.65 ± 0.41 ms in the right side. Mean SMNLTSS of patients before operation was 3.71 ± 0.48 ms in the left side and 3.86 ± 0.37 ms in the right side. Mean SMNLTSS of the seven patients without any soiling was 3.96 ± 0.42 ms in the left side and 3.92 ± 0.37 ms in the right side, whereas mean SMNLTSS of five patients with some degree of soiling was 4.93 ± 0.45 ms in the left side and 4.96 ± 0.63 ms in the right side (Fig. 6). Conduction delay of SMNLTSS in the soiling group was significantly longer than that of the continent group, patients before operation, or controls ($P < 0.01$, respectively). However, no significant differences in conduction delay between the continent group and controls were noted. No significant differences in conduction delay between patients before operation and controls were noted. These results suggest that damage to the sacral motor nerves may well be a cause of the soiling that is seen after ileal J-pouch-anal anastomosis.

DISCUSSION

Although functional results in most large series of patients who have undergone colectomy with mucosal proctectomy and ileal J-pouch-anal anastomosis have been encouraging,[3, 7, 8] a 20 to 60 percent[5, 14] incidence of some degree of soiling has been reported. Some 41.7 percent (5/12) of our patients after ileal J-pouch-anal anastomosis occasionally had a small amount of soiling. Soiling was present in 50 percent (4/8) of patients with UC and 25 percent (1/4) of patients with AC. Anorectal manometric studies conducted on patients with soiling revealed decreased resting and squeeze pressure, which reflected abnormalities in contractility of the internal and external anal sphincter muscles, possibly caused by stretch injury to the anal canal during surgery.[15] In previous studies,[16] we reported that patients with soiling after J-pouch-anal anastomosis also showed decreased resting and squeeze pressures; these results were probably the result of remaining inflammation at the internal anal sphincter muscle in UC with soiling and caused by injury to the external and internal anal sphincter muscles during surgery. Continence is maintained by reflex contraction of the internal anal and/or external anal sphincter/puborectalis complex.[17] Assessment of the effects of the puborectalis muscle cannot be obtained from studies on anorectal manometry. There were only a few reports[17–19] regarding neurologic assessment in the external anal sphincter and puborectalis muscles. The external anal sphincter muscle is innervated by pudendal nerves. Puborectalis muscle is innervated largely by direct branches from the S2–4 motor roots in the pelvic plexus. However, there have been no reports of data on conduction time in the pudendal and sacral motor nerves after ileal J-pouch-anal anastomosis for UC and AC. Therefore, we investigated nerve conduction time of pudendal and sacral motor nerves in patients with ileal J-pouch-anal anastomosis who were divided into a group that were continent (7 cases) and a group that experienced soiling (5 cases). Investigations were performed by a new electrophysiologic procedure.

Conduction times of pudendal and sacral motor nerves were measured by Kiff and Swash in 1984.[18, 19] Pudendal nerves innervating the external anal sphincter muscle can be excited by transrectal stimulation, and terminal motor latencies can be recorded. Nerves innervating the puborectalis muscle can be excited transcutaneously by stimulating the spinal column overlying the *cauda equina*, thus allowing measurement of motor latency to this muscle. They reported that idiopathic fecal incontinence is caused by damage to the pudendal nerve and sacral motor nerve by stretch injury to these nerves during perineal descent associated with prolonged and repeated defecation straining. These methods are mainly used to clarify the pathophysiology of pelvic floor disorders and intractable constipation. The present study shows that conduction delay of PNTML and SMNLTSS was the longest in patients with soiling, followed by those who are incontinent, patients before operation, and controls in decreasing order. Patients before operation demonstrated conduction delay in pudendal and sacral nerves rather than controls, and these results may be stretch injury to both nerves during repeated defecation (5–7 times per day) before operation. Our findings of delayed nerve conduction in pudendal and sacral motor nerves indicate neurogenic damage to external anal sphincter and puborectalis muscle; nerve damage is remarkably symmetrical for both pudendal and sacral measurements. These results suggest that direct nerve damage may be contributory, as by similar stretch injury of the anal canal and levator ani diaphragm to every direction during the operation. Recently, technical improvement in pouch construction and anastomosis techniques using a double staple technique have emphasized avoidance of sphincter stretch injury in an effort to improve functional results.[20] Our data suggest that functional results of both patients after operation with UC and AC are probably more related to technical factors in handsewn ileal J-pouch-anal anastomosis. A double staple technique may give the best functional result in defecation among patients with UC and AC.

Diagnostic electrophysiologic tests such as PNTML and SMNLTSS measurements are valuable because they directly assess the underlying abnormality, which consists of damage to the innervation of the external anal sphincter and puborectalis muscles.[21] Especially, the nerve stimulation technique using a magnetic stimulator may be useful in pinpointing the puborectalis muscle lesion that is causing soiling and incontinence. The pathophysiology of anorectal dysfunction after ileal J-pouch-anal anastomosis will be established by a combination of clinical findings, anorectal manometry, and electrophysiologic methods in the future.

REFERENCES

1. Ravitch MM, Sabitson DC. Anal ileostomy with preservation of sphincter: a proposed operation in patients requiring total colectomy for benign lesions. Surg Gynecol Obstet 1947;84:1095–9.
2. Peck DA. Rectal mucosal replacement. Ann Surg 1980; 191:294–304.
3. Utunomiya J, Iwama T, Imajo M, *et al.*. Total colectomy, mucosal protectomy and ileoanal anastomosis. Dis Colon Rectum 1980;23:459–66.
4. Hepell J, Kelly KA, Phillips SF, Beart RW, Telander RL, Perraut JP. Physiologic aspects of continence after colectomy, mucosal proctectomy, and endorectal ileoanal anastomosis. Ann Surg 1982;195:435–43.
5. Kurosu Y. Total colectomy, mucosal proctectomy and ileo-anal anastomosis with ileal reservoir for ulcerative colitis and familial polyposis. Nihon Univ J Med 1989; 31:207–15.
6. Becker JM. Ileal pouch-anal anastomosis: current status and controversies. Surg 1993;113:599–602.
7. Grant D, Cohen Z, McHugh S, McLeod R, Stern H. Restorative proctectomy, clinical results and manometric findings with long and short rectal cuff. Dis Colon Rectum 1986;29:27–32.
8. RonanO'Connel P, Stryker SJ, Metcaf AM, Pemberton JH, Kelly KA. Anal canal pressure and motility after ileoanal anastomosis. Surg Gynecol Obstet 1988;166: 47–54.
9. Taylor BM, Cranley BC, Kelly KA, Phillips SF, Beart RW, Dozois RR. A clinico-physiological comparison of ileal pouch-anal and straight ileoanal anastomosis. Ann Surg 1983;198:462–8.
10. Stryker SJ, Phillips SD, Kelly KA. Anal and neorectal function after ileal pouch-anal anastomosis. Ann Surg 1986:203:55–61.
11. Hatakeyama K, Shimamura K, Muto T, Yamai K. Defecating function after ileal W pouch-anal anastomosis for restorative proctocolectomy: an evaluation by age. Acta Med Biol 1991;39:181–4.
12. Pembert JH. Neorectum and assessment of anorectal function following surgery. In: Kumar D, Waldron DJ, Williams NS, eds. Clinical measurement in coloproctology. London: Springer-Verlag, 1991:165–88.
13. Levitt MD, Kamm MA, Groom J, Hawley PR, Nicholls RJ.

Ileoanal pouch compliance and motor function. Br J Surg 1992;79:126–8.

14. Tjandra JJ, Fazio VW, Church JM, Oakley JR, Milson JW, Lavery IC. Similar function results after restorative proctocolectomy in patients with familial adenomatous polyposis and mucosal ulcerative colitis. Am Surg 1993; 165:322–5.
15. Cemlo BT, Wong WD, Rothenberger DA, Goldberg SM. Ileal pouch-anal anastomosis: patterns of failure. Arch Surg 1992;127:784–7.
16. Tomita R, Kurosu Y, Isozumi M, Tanjoh K, Munakata K. A pathophysiological study using manometry on patients with soiling after ileal J pouch-anal anastomosis (in Japanese with English abstract). Jpn J Gastroenterol Surg 1994;27:2551–6.
17. Read NW, Sun WM. Anorectal manometry, anal myography and rectal sensory testing. In: Read NW, eds. Gastrointestinal motility: which test? Petersfield: Wrightson Biomedical, 1989:227–41.
18. Kiff ES, Swash M. Slowed conduction in the pudendal nerves in idiopathic (neurogenic) faecal incontinence. Br J Surg 1984;71:614–6.
19. Kiff ES, Swash M. Normal proximal and delayed distal conduction in the pudendal nerves of patients with idiopathic (neurological) faecal incontinence. J Neurol Neurosurg Psychiatry 1984;47:820–3.
20. Gemlo BT, Wong WD, Rothenberger DA, Goldberg SM. Ileal pouch-anal anastomosis. Arch Surg 1992;127: 784–7.
21. Wald A. Anorectum. In: Schuster MM, ed. Atras of gastrointestinal motility in healthy and disease. Baltimore: William and Wilkins, 1993:229–49.