Original article

External anal sphincter atrophy on endoanal magnetic resonance imaging adversely affects continence after sphincteroplasty

J. W. Briel, J. Stoker*, E. Rociu*, J. S. Laméris*, W. C. J. Hop† and W. R. Schouten

Departments of Surgery, *Radiology, and †Epidemiology and Biostatistics, University Hospital Rotterdam, Dr Molewaterplein 40, 3015 GD Rotterdam, The Netherlands
Correspondence to: Dr W. R. Schouten

Background: There is still considerable debate about the value of preoperative anorectal physiological parameters in predicting the clinical outcome after sphincteroplasty. Recently it has been reported that atrophy of the external anal sphincter can be clearly shown with endoanal magnetic resonance imaging (MRI). The aims of this study were to investigate the prevalence of external anal sphincter atrophy in women with anterior sphincter defects due to obstetric injury and to determine the impact of external anal sphincter atrophy on the outcome of sphincteroplasty.

Methods: In this prospective study, 20 consecutive women (median age 50 (range 28–75) years) with faecal incontinence due to obstetric trauma were assessed before operation with endoanal ultrasonography and endoanal MRI. The external anal sphincter was examined and evaluated for the presence of atrophy. The clinical outcome of sphincteroplasty was interpreted without knowledge of the magnetic resonance and ultrasonographic images.

Results: In all patients anterior sphincter defects could be demonstrated with ultrasonography and MRI. External anal sphincter atrophy could only be demonstrated on MRI. Eight of 20 patients had external anal sphincter atrophy. Continence was restored in 13 patients. Outcome was significantly better in those without external anal sphincter atrophy (11 of 12 patients *versus* two of eight; $P = 0{\cdot}004$).

Conclusion: External anal sphincter atrophy can only be visualized on endoanal MRI and affects continence after sphincteroplasty. Endoanal MRI is valuable in the preoperative assessment of patients with faecal incontinence.

Presented to the American Society of Colon and Rectal Surgeons in Philadelphia, Pennsylvania, USA, June 1997

Paper accepted 7 June 1999

British Journal of Surgery 1999, **86**, 1322–1327

Introduction

Childbirth is the most common cause of faecal incontinence[1]. Following primary gynaecological repair of perineal tears, persistent defects can be demonstrated in 85 per cent of patients[2]. A substantial proportion of patients with an occult sphincter defect will become incontinent with increasing age. The incidence of occult sphincter damage after childbirth was unknown until Sultan *et al.*[3] studied a consecutive group of 202 pregnant women. On endoanal ultrasonography, 35 per cent of primiparae who delivered vaginally developed a sphincter defect involving one or both muscles, which persisted at 6 months. Although sphincter defects due to obstetric trauma can be restored adequately by overlapping sphincteroplasty, incontinence persists in a substantial number of patients. The reported failure rates at long-term follow-up vary between 4 per cent[4] and 53 per cent[5].

Preoperative evaluation of patients with faecal incontinence usually includes anorectal manometry, evacuation proctography, assessment of pudendal nerve terminal motor latency and endoanal ultrasonography. The role of these preoperative anorectal function tests in predicting the outcome of sphincteroplasty is still controversial. Reports about the predictive value of these tests are numerous and conflicting.

Recently, it has been shown that endoanal magnetic resonance imaging (MRI) enables the detection of external anal sphincter atrophy[6–10] (*Figs 1* and *2*). Using conventional endoanal ultrasonography, atrophy cannot be de-

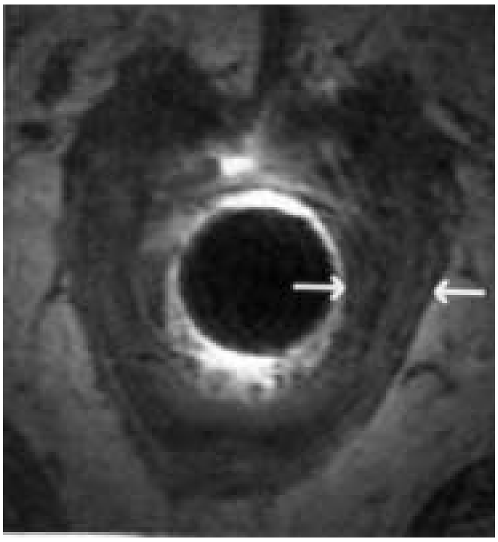

Fig. 1 Normal external anal sphincter on endoanal magnetic resonance imaging with anterior sphincter defect; arrows indicate relatively dark grey external anal sphincter

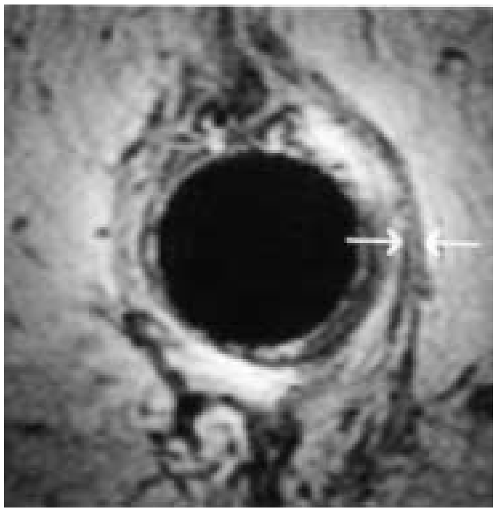

Fig. 2 Atrophic external anal sphincter on endoanal magnetic resonance imaging with anterior sphincter defect; arrows indicate relatively dark grey external anal sphincter

monstrated. The main disadvantages with MRI are the time required and the cost of an examination, which are both greater than those of endoanal ultrasonography. Therefore preoperative endoanal MRI is only justified if it influences surgical decision making or predicts final outcome. A prospective study was conducted to investigate the prevalence of external anal sphincter atrophy in women with anterior sphincter defects due to obstetric injury. The impact of external anal sphincter atrophy on the outcome of sphincteroplasty was also studied.

Patients and methods

Twenty consecutive women (median age 50 (range 28–75) years) with faecal incontinence due to obstetric trauma were assessed clinically by means of history and digital examination, and by preoperative anal manometry, endoanal ultrasonography and endoanal MRI. Both sphincters were examined and external anal sphincter atrophy was scored. Within 6 months of the preoperative assessment, all patients underwent anterior anal repair, as described earlier[11]. All repairs were performed by one surgeon (W.R.S.).

Clinical outcome was evaluated using the grade and frequency of faecal incontinence, the need for pads, the grade of social isolation and patient satisfaction after a median follow-up of 1 year. The degree of incontinence was graded as described by Parks[12]: grade I, fully continent; grade II, soiling and incontinence for gas; grade III, incontinence for liquids; and grade IV, incontinence for solid stool. Restoration of continence from grade IV to grade II or I, or from grade III to grade I, was defined as a successful outcome. Outcome was interpreted without knowledge of the magnetic resonance and ultrasonography images.

The decision to perform surgery was based solely on endosonography. MRI was considered additional and did not influence treatment.

Endoanal sonography

A Brüel & Kjaer (Naerum, Denmark) ultrasound scanner was used with a rotating probe providing a 360° image. A 7-MHz transducer, with minimum beam width of 1·1 mm and a focal length of about 3 cm, was used. Transverse images were obtained, at least at four different levels, through the anal canal.

Endoanal magnetic resonance imaging

MRI was performed at 0·5 T (Gyroscan T5-II; Philips Medical Systems, Best, The Netherlands). An endoanal coil with a diameter of 19 mm (Philips Medical Systems) was used[7–9]. Axial T2-weighted three-dimensional gradient echo and coronal and sagittal T2-weighted turbo spin-echo sequences were performed.

Determination of atrophy

External anal sphincter atrophy was assessed on hard copy by one radiologist (J.S.). To determine sphincter damage with endoanal MRI, as no criteria exist, normal endoanal MRI findings were used as a reference[7]. Atrophy of the external anal sphincter was defined as extreme thinning of its sphincter fibres or generalized fatty infiltration. The magnetic resonance images were also evaluated quantitatively using a work station with commercially available software (Gyroview HR; Philips Medical Systems). In all cases the anterior part of the external anal sphincter could not be identified because of an anterior sphincter defect. External anal sphincter width at the posterior side and at both lateral sides was determined. Furthermore, the arc of the anterior defect was noted. The area of the remaining part of the external anal sphincter was measured (*Fig. 3*). All measurements were performed on the MRI slice located at the mid-level of the anal canal, in each patient. This level of the anal canal was chosen based on normal anatomy findings using endoanal MRI[7]. At the lowest part of the anal canal, the external anal sphincter consists of two halves embedded within the ischioanal space. Cranial to this level, the two lateral halves of the external anal sphincter are connected to each other anteriorly. Just slightly more cranial to this level the external sphincter becomes completely circular, representing the mid-level, which was measured in the present study. More cranial to this level, the puborectalis muscle is first seen on endoanal MRI.

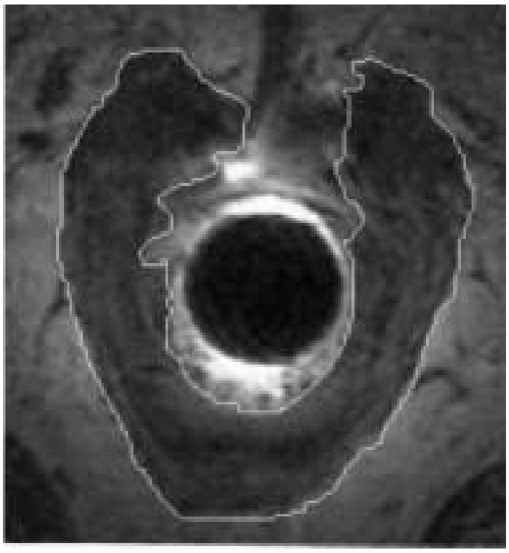

Fig. 3 Endoanal magnetic resonance imaging showing delineation of area on the image. Area is calculated by the integral software

To investigate the possibility of interobserver bias, the results of quantitative MRI assessment performed by two investigators (J.W.B. and E.R.) were compared. Each was blinded to the measurements of the other.

Statistical analysis

Fisher's exact test was used for the comparison of percentages. Mann–Whitney test was used to compare continuous data between groups. To determine agreement between measurements of different investigators, the intraclass correlation coefficient was used. $P = 0.05$ was considered the limit of significance.

Results

In all patients anterior sphincter defects were demonstrated with ultrasonography and MRI. Qualitative or semiquantitative measurement of the thickness of the external sphincter muscle was not feasible on endoanal ultrasonography. External anal sphincter atrophy could only be demonstrated on endoanal MRI. The prevalence of external anal sphincter atrophy (determined by one of the radiologists) was 40 per cent (eight of 20 patients). Continence was restored in 13 patients. Comparing patients with and without atrophy, clinical outcome was significantly better in those without external anal sphincter atrophy (11 of 12 *versus* two of eight; $P = 0.004$).

The MRI measurements are listed in *Table 1*. Determination of external anal sphincter width at the posterior side and both lateral sides was shown not to be useful in predicting the outcome of sphincter repair. However, there was a significant relationship between the outcome of sphincteroplasty and the arc of the external anal sphincter defect ($P = 0.04$). Furthermore, the area of the remaining external anal sphincter was related to outcome ($P = 0.002$). Of these two parameters, the area of the remaining external anal sphincter was the better predictor (*Table 1*).

Table 1 Magnetic resonance imaging measurements in patients with poor and good outcome after sphincter repair

	Good outcome	Poor outcome	*P*
Width (mm)			
Posterior	9·3 (2·0–23·5)	9·3 (4·7–13·1)	0·12
Left	4·3 (1·1–8·8)	2·5 (1·1–5·6)	0·22
Right	3·9 (1·1–9·0)	3·0 (1·1–6·0)	0·73
Arc (°)	55 (19–146)	85 (51–190)	0·04
Area (mm^2)	393 (121–1350)	218 (87–360)	0·002

Values are median (range). Mann–Whitney *U* test

For area of the remaining external anal sphincter, the cut-off point for successful outcome was determined. The greatest area in patients with a poor outcome after sphincteroplasty was 360 mm^2 (*Fig. 4*). Of the ten patients with an area of 360 mm^2 or less, only three had a successful outcome after sphincter repair. All ten patients with an external sphincter area greater than 360 mm^2 regained continence. A receiver operating characteristic curve was calculated for the cut-off point of area (*Fig. 5*). For a cut-off point of 300 mm^2, the sensitivity and specificity were 92 and 86 per cent respectively. For an area of 360 mm^2, they were 77 and 100 per cent.

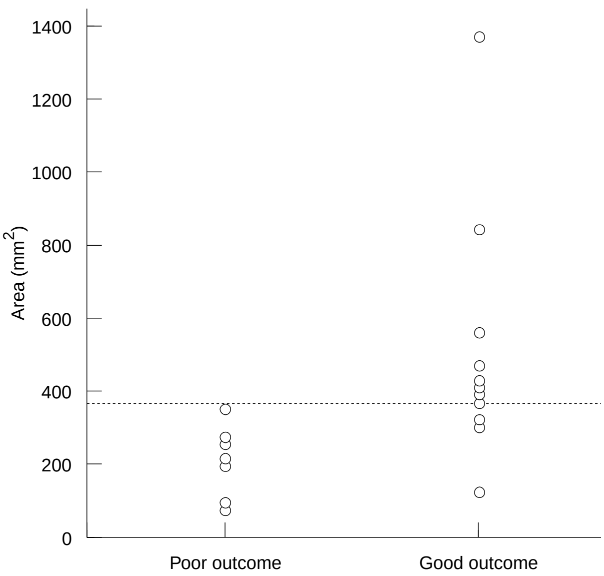

Fig. 4 Outcome of sphincter repair related to preoperative external anal sphincter area

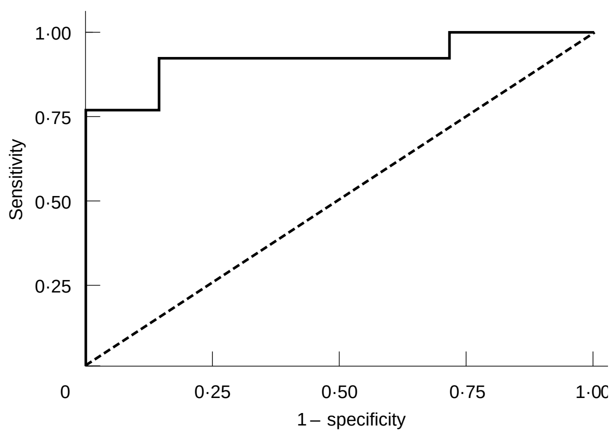

Fig. 5 Receiver operating characteristic curve (solid line) to demonstrate cut-off points of area; dotted line, base line

Atrophy, as assessed by one radiologist, and the quantitative measurement of area on MRI were well related ($P = 0·001$). In patients with atrophy, as described by the radiologist, the measured area was significantly lower than that in patients without radiological signs of external anal sphincter atrophy (214 *versus* 399 mm^2; $P = 0·001$).

Comparing the quantitative measurements of the two investigators (J.W.B. and E.R.), there was no systemic difference ($P = 0·67$). The interobserver agreement was good (intraclass correlation coefficient 0·91).

Age and surgical outcome were not related. There was also no significant correlation between age and atrophy. Furthermore, age was not related to any of the MRI measurements (width, arc or area).

Discussion

The use of conventional whole-body MRI in the evaluation of patients with faecal incontinence has been proven to be of great value in assessing patients with congenital anorectal anomalies[13]. However, anal endosonography is the imaging technique of choice for the detection of abnormalities in the region of the anal sphincters, when compared with MRI using a whole-body receiver coil[14–16]. The spatial resolution of endoanal sonography is superior to that of body coil MRI. However, a major limitation of anal endosonography is the poor inherent contrast, which makes it difficult to identify the external anal sphincter. Recently, it has been shown that the use of an endoanal coil enables the detection of anal sphincter defects as well as external anal sphincter atrophy on MRI[6,8,9]. Moreover, the sensitive region of the coil extended beyond the region normally visualized with endoanal ultrasonography. In this study the value of preoperative endoanal MRI was assessed.

Anterior sphincteroplasty was found to be successful in 13 of 20 patients in the present study. This outcome is in accordance with other series[4,5]. External anal sphincter atrophy was present in eight of the 20 patients.

In 1977, Parks[17] examined biopsies of the external anal sphincter of patients with idiopathic faecal incontinence. The biopsies of all incontinent patients showed histological evidence of denervation. He therefore suggested that this type of faecal incontinence could result from denervation of muscles of the anal sphincter mechanism. This could be the result of entrapment or stretch injury of the pudendal or perineal nerves occurring as a consequence of rectal descent induced during repeated defaecation straining in constipated patients[18], or from injuries to these nerves associated with childbirth[19]. Nowadays this type of faecal incontinence is called neurogenic.

In patients with faecal incontinence due to obstetric injury both anal sphincter rupture and denervation may coexist[20–22]. Several authors have reported that denervation of the pelvic floor and subsequent failure of surgical repair can be predicted by preoperative electromyography[5,20,23–25]. In contrast, other authors were not able to confirm these findings[26–28]. Also, denervation of the external anal sphincter and its detection fade in time while the sphincter damage remains. Furthermore, electromyography of the pelvic floor is generally considered to be distressing. It seems likely that in patients with both denervation and sphincter defects, denervation of the pelvic floor will persist, regardless of the outcome of repair of the sphincter defect. It has been shown that functional results of sphincter repair in patients with neurogenic faecal incontinence are poor[29]. Therefore, in patients with both denervation and sphincter defects, a poor outcome might be expected.

If traumatic denervation leads to atrophy of the external anal sphincter, the finding of atrophy of this sphincter muscle will influence outcome after surgery. This hypothesis was confirmed by the present study. Outcome was significantly better in those without external anal sphincter atrophy. The area of the remaining external anal sphincter on endoanal MRI appeared to be of significant value in identifying patients with a favourable outcome. The objective quantitative measurement of this area was of equal value as the rather subjective determination of atrophy on hard copies of magnetic resonance images by the radiologist; the two methods were well correlated ($P = 0{\cdot}001$). The separate measurements of sphincter width at the posterior side and both lateral sides did not relate to outcome. This might be explained by the isolated value of the width measurement. The computed area consists of numerous adjacent sphincter width measurements, thereby overcoming the effect of sphincter irregularity. Determination of the presence of atrophy on endoanal MRI may enable the prediction of outcome after sphincteroplasty. Patients below the cut-off area (360 mm^2) are less likely to benefit from sphincter repair. Confirmation of this cut-off value in another group of patients is necessary.

Endoanal MRI is the first imaging technique to predict functional outcome after sphincter repair. Moreover, it directly enables the detection of external sphincter atrophy, rather than assuming atrophy by detection of pelvic floor denervation assessed by either electromyography or pudendal nerve terminal motor latencies. The authors advocate the inclusion of endoanal MRI in the preoperative work-up of patients with faecal incontinence to help predict the outcome of surgery in individual patients.

The alternatives for patients with persistent faecal incontinence after sphincteroplasty are either creation of a stoma or dynamic gracilis plasty. Since dynamic gracilis plasty is technically easier in patients in whom previous attempts to restore continence (i.e. sphincteroplasty) have not been made, selection of patients is preferable. Therefore, patients with external anal sphincter atrophy as seen on endoanal MRI might be candidates for dynamic gracilis plasty in the first place.

References

1 Ctercteko GC, Fazio VW, Jagelman DG, Lavery IC, Weakley FL, Melia M. Anal sphincter repair: a report of 60 cases and review of the literature. *Aust N Z J Surg* 1988; **58:** 703–10.

2 Sultan AH, Kamm MA, Hudson CN, Bartram CI. Third degree obstetric anal sphincter tears: risk factors and outcome of primary repair. *BMJ* 1994; **308:** 887–91.

3 Sultan AH, Kamm MA, Hudson CN, Thomas JM, Bartram CI. Anal-sphincter disruption during vaginal delivery. *N Engl J Med* 1993; **329:** 1905–11.

4 Fang DT, Nivatvongs S, Vermeulen FD, Herman FN, Goldberg SM, Rothenberger DA. Overlapping sphincteroplasty for acquired anal incontinence. *Dis Colon Rectum* 1984; **27:** 720–2.

5 Laurberg S, Swash M, Henry MM. Delayed external sphincter repair for obstetric tear. *Br J Surg* 1988; **75:** 786–8.

6 deSouza NM, Puni R, Gilderdale DJ, Bydder GM. Magnetic resonance imaging of the anal sphincter using an internal coil. *Magnetic Resonance Quarterly* 1995; **11:** 45–56.

7 Hussain SM, Stoker J, Laméris JS. Anal sphincter complex: endoanal MR imaging of normal anatomy. *Radiology* 1995; **197:** 671–7.

8 Stoker J, Hussain SM, van Kempen D, Elevelt AJ, Laméris JS. Endoanal coil in MR imaging of anal fistulas. *AJR Am J Roentgenol* 1996; **166:** 360–2.

9 Hussain SM, Stoker J, Schouten WR, Hop WC, Laméris JS. Fistula *in ano*: endoanal sonography *versus* endoanal MR imaging in classification. *Radiology* 1996; **200:** 475–81.

10 deSouza NM, Kmiot WA, Puni R, Hall AS, Burl M, Bartram CI *et al.* High resolution magnetic resonance imaging of the anal sphincter using an internal coil. *Gut* 1995; **37:** 284–7.

11 Briel JW, de Boer LM, Hop WCJ, Schouten WR. Clinical outcome of anterior overlapping external anal sphincter repair with internal anal sphincter imbrication. *Dis Colon Rectum* 1998; **41:** 209–14.

12 Parks AG. Anorectal incontinence. *Proc R Soc Med* 1975; **68:** 681–90.

13 Sato Y, Pringle KC, Bergman RA, Yuh WT, Smith WL, Soper RT *et al.* Congenital anorectal anomalies: MR imaging. *Radiology* 1988; **168:** 157–62.

14 Sultan AH, Kamm MA, Hudson CN, Nicholls JR, Bartram CI. Endosonography of the anal sphincters: normal anatomy and comparison with manometry. *Clin Radiol* 1994; **49:** 368–74.

15 Sultan AH, Nicholls RJ, Kamm MA, Hudson CN, Beynon J, Bartram CI. Anal endosonography and correlation with *in vitro* and *in vivo* anatomy. *Br J Surg* 1993; **80:** 508–11.

16 Schafer A, Enck P, Furst G, Kahn T, Frieling T, Lubke HJ. Anatomy of the anal sphincters. Comparison of anal endosonography to magnetic resonance imaging. *Dis Colon Rectum* 1994; **37:** 777–81.

17 Parks AG, Swash M, Urich H. Sphincter denervation in anorectal incontinence and rectal prolapse. *Gut* 1977; **18:** 656–65.

18 Kiff ES, Barnes PRH, Swash M. Evidence of pudendal neuropathy in patients with perineal descent and chronic straining at stool. *Gut* 1984; **25:** 1279–82.

19 Snooks SJ, Setchell M, Swash M, Henry MM. Injury to innervation of pelvic floor sphincter musculature in childbirth. *Lancet* 1984; **ii:** 546–50.

20 Jacobs PPM, Scheuer M, Kuijpers JHC, Vingerhoets MH. Obstetric fecal incontinence. Role of pelvic floor denervation and results of delayed sphincter repair. *Dis Colon Rectum* 1990; **33:** 494–7.

21 Felt-Bersma RJF, Cuesta MA, Koorevaar M, Strijers RI, Meuwissen SG, Dercksen EJ *et al.* Anal endosonography: relationship with anal manometry and neurophysiologic tests. *Dis Colon Rectum* 1992; **35:** 944–9.

22 Cuesta MA, Meijer S, Derksen EJ, Boutkan H, Meuwissen SG. Anal sphincter imaging in fecal incontinence using endosonography. *Dis Colon Rectum* 1992; **35:** 59–63.

23 Yoshioka K, Keighley MRB. Sphincter repair for fecal incontinence. *Dis Colon Rectum* 1989; **32:** 39–42.

24 Infantino A, Melega E, Negrin P, Masin A, Carnio S, Lise M. Striated anal sphincter electromyography in idiopathic fecal incontinence. *Dis Colon Rectum* 1995; **38:** 27–31.

25 Wexner SD, Marchetti F, Jagelman DG. The role of sphincteroplasty for fecal incontinence reevaluated: a prospective physiologic and functional review. *Dis Colon Rectum* 1991; **34:** 22–30.

26 Young CJ, Mathur MN, Eyers AA, Solomon MJ. Successful overlapping anal sphincter repair: relationship to patient age, neuropathy, and colostomy formation. *Dis Colon Rectum* 1998; **41:** 344–9.

27 Engel AF, Kamm MA, Sultan AH, Bartram CI, Nicholls RJ. Anterior anal sphincter repair in patients with obstetric trauma. *Br J Surg* 1994; **81:** 1231–4.

28 Chen AS, Luchtefeld MA, Senagore AJ, Mackeigan JM, Hoyt C. Pudendal nerve latency. Does it predict outcome of anal sphincter repair? *Dis Colon Rectum* 1998; **41:** 1005–9.

29 Briel JW, Schouten WR. Disappointing results of postanal repair in the treatment of fecal incontinence. *Ned Tijdschr Geneeskd* 1995; **139:** 23–6.

