

# Can the outcome of pelvic-floor rehabilitation in patients with fecal incontinence be predicted?

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## Abstract

**Purpose** Pelvic-floor rehabilitation does not provide the same degree of relief in all fecal incontinent patients. We aimed at studying prospectively the ability of tests to predict the outcome of pelvic-floor rehabilitation in patients with fecal incontinence.

**Materials and methods** Two hundred fifty consecutive patients (228 women) underwent medical history and a standardized series of tests, including physical examination, anal manometry, pudendal nerve latency testing, anal

sensitivity testing, rectal capacity measurement, defecography, endoanal sonography, and endoanal magnetic resonance imaging. Subsequently, patients were referred for pelvic-floor rehabilitation. Outcome of pelvic-floor rehabilitation was quantified by the Vaizey incontinence score. Linear regression analyses were used to identify candidate predictors and to construct a multivariable prediction model for the posttreatment Vaizey score.

**Results** After pelvic-floor rehabilitation, the mean baseline Vaizey score (18,  $SD\pm 3$ ) was reduced with 3.2 points ( $p <$

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0.001). In addition to the baseline Vaizey score, three elements from medical history were significantly associated with the posttreatment Vaizey score (presence of passive incontinence, thin stool consistency, primary repair of a rupture after vaginal delivery at childbed) ( $R^2$ , 0.18). The predictive value was significantly but marginally improved by adding the following test results: perineal and/or perianal scar tissue (physical examination), and maximal squeeze pressure (anal manometry;  $R^2$ , 0.20;  $p=0.05$ ).

**Conclusion** Additional tests have a limited role in predicting success of pelvic-floor rehabilitation in patients with fecal incontinence.

**Keywords** Fecal incontinence · Outcome prediction · Diagnostic tests · Biofeedback · Electrical stimulation therapy · Pelvic floor

## Introduction

Fecal incontinence is a common [1, 2] disabling condition that affects the lifestyle of patients [3]. Continence is a multi-factorial mechanism, requiring an intact chain of anatomical structures and physiological mechanisms [4]. Fecal incontinence is primarily caused by anal sphincter defects, neuropathy, reduced rectal capacity and compliance, or a combination of these factors [4].

There is a wide variety of treatment options available for patients with fecal incontinence ranging from conservative therapy [dietary measures (fibers, avoidance of foods that cause diarrhea or urgency), medical treatment (anti-diarrhea medications, bulking agents), pelvic-floor rehabilitation] to surgical intervention [4]. Biofeedback and electrical stimulation are both pelvic-floor rehabilitation techniques commonly used in patients with fecal incontinence. The outcome of these treatment modalities alone or in combi-

nation has been extensively evaluated, leading to a wide range of reported success rates [5–8]. Some of this variability can be explained by between-study differences in patient selection, methodology, biofeedback and/or electrical stimulation techniques used, outcome measurements, criteria for success, and duration of follow-up [4, 9–11]. A recent study evaluating pelvic-floor rehabilitation (pelvic-floor muscle training with biofeedback and electrical stimulation) in a large population with fecal incontinence due to different etiologies, demonstrated that pelvic-floor rehabilitation provides a “slight” relief of fecal incontinence complaints (a reduction in Vaizey score of <50%) in the majority of patients and a “substantial” relief (a reduction in Vaizey score of  $\geq 50\%$ ) in a minority only [12]. Identification of factors predictive of the response to pelvic-floor rehabilitation would be helpful in selecting patients for pelvic-floor rehabilitation and counseling patients on the likely outcome of pelvic-floor rehabilitation [13, 14]. To select patients who may benefit from pelvic-floor rehabilitation, an accurate evaluation of the underlying pathophysiology and an understanding of the likely cause of fecal incontinence are crucial [13, 14].

Additional to medical history, several tests can be used to assess patients with fecal incontinence, including physical examination, anorectal functional tests, and imaging techniques [4, 15, 16]. Up until now, there is no consensus regarding which tests should be performed in patients with fecal incontinence and what their utility is in selecting patients for pelvic-floor rehabilitation [13, 14, 17].

The purpose of this study was to prospectively determine the value of tests, in isolation and in combination, to predict the outcome of pelvic-floor rehabilitation in a large series of patients with fecal incontinence due to different etiologies.

## Materials and methods

### Patients

This prospective study was performed between December 2001 and April 2005 in 16 medical centers in the Netherlands. The Medical Ethics Committees of all hospitals approved the study.

Consecutive patients with fecal incontinence were invited. Inclusion criteria were fecal incontinence complaints for at least 6 months, a Vaizey incontinence score of at least 12 [18], and failure of conservative treatment (including diet measurements and medication). Patients under 18, patients diagnosed with an anorectal tumor, patients with chronic diarrhea (always fluid stools, three or more times a week), overflow incontinence, proctitis, soiling (leakage of fecal material out of the anus after normal defecation often leading to perineal eczema), previous ileoanal or coloanal anastomosis, and rectal

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prolapse were excluded, as were patients who had received pelvic-floor rehabilitation in the previous 6 months. Patients who were considered to be unable to undergo pelvic-floor rehabilitation because of limited comprehension or intellectual capacity were also excluded.

Eligible patients were asked for signed informed consent. Participating patients underwent medical history and a standardized series of tests, consisting of physical examination, a set of anorectal functional tests, and imaging techniques. As not all participating centers were well equipped to perform each of the anorectal functional tests and/or imaging techniques, patients from these centers were referred to one of the other participating centers to undergo the specific examinations. After testing, all patients were referred for a standardized pelvic-floor rehabilitation program. The outcome of pelvic-floor rehabilitation will be reported elsewhere. This study focuses on the predictive value of medical history and additional tests.

### Medical history

Medical history was obtained by physicians and included duration, type, and degree of fecal incontinence, as well as bowel habits and likely underlying causes for fecal incontinence. All participating physicians used the same structured forms to obtain information from medical history. The type of incontinence was divided in passive incontinence (defecation loss without the patient's knowledge) and urge incontinence (unwanted loss of stool despite active attempts to inhibit defecation) [14, 19]. Degree of fecal incontinence was assessed according to the grading system of Vaizey [18]. This grading system contains several quantitative and qualitative incontinence-specific items, and the total score ranges from 0 (complete continence) to 24 (complete incontinence). Bowel habits comprised frequency of defecation ( $\leq 7$ /week or  $> 7$ /week), stool consistency (thin, soft mushy, solid, firm, varying) and sensation of incomplete evacuation ( $< 1$ /week or  $\geq 1$ /week). The likely underlying causes for fecal incontinence were divided in relevant subgroups reflecting the whole spectrum of causes of fecal incontinence (Table 1).

### Additional tests

All tests were performed by specialized physicians or technicians according to a standard procedure that had been established during joined meetings of the research group members of all participating hospitals.

### Physical examination

Physical examination comprised inspection of the perineum and perianal area for presence of scar tissue and digital rectal examination [16]. Digital rectal examination assessed

**Table 1** Association between candidate predictors from medical history and posttreatment Vaizey score after adjustment for baseline Vaizey score

Medical history	Value	$\beta$	<i>p</i>
Vaizey score at baseline, points ( $\pm$ SD)*	18 ( $\pm 3$ )	0.61	0.00*
Gender (female)	228 (91%)	-1.3	0.16
Age, year ( $\pm$ SD)	59 ( $\pm 13$ )	-0.03	0.23
Duration of fecal incontinence, year ( $\pm$ SD)	8 ( $\pm 9$ )	-0.05	0.19
Presence of urge incontinence	241 (96%)	1.67	0.35
Presence of passive incontinence*	145 (58%)	1.54	0.02*
Frequency defecation ( $< 7$ times/week)	189 (76%)	0.44	0.57
Sensation of incomplete evacuation ( $\geq 1$ /week)	142 (57%)	1.11	0.10
Thin stool consistency*	9 (4%)	4.31	0.01*
Soft mushy stool consistency	79 (32%)	0.16	0.82
Solid stool consistency	57 (23%)	-1.2	0.12
Firm stool consistency	9 (4%)	1.55	0.37
Varying stool consistency	90 (36%)	-0.21	0.75
Rupture after vaginal delivery repaired at childbed*	84 (34%)	1.75	0.01*
Rupture after vaginal delivery repaired at operating room	31 (12%)	-0.38	0.7
Any obstetric risk factor (e.g., high-birth-weight infant, long second stage of labor, instrumental delivery)	190 (76%)	-2.58	0.74
Any ano- and colorectal risk factor (e.g., surgery for anal fistulas, anal fissures, hemicolectomy)	69 (28%)	0.48	0.52
Any gynecological risk factor (e.g., hysterectomy)	99 (40%)	1.03	0.12
Any urological risk factor (e.g., Burch operation)	47 (19%)	0.77	0.36
Any neurological risk factor (e.g., cerebral and spinal cord disorders)	32 (13%)	-0.54	0.58
Any metabolic risk factor (e.g., diabetes mellitus, thyroid disorders)	33 (13%)	0.44	0.65
Any fecal consistency risk factor (e.g., diverticulitis)	9 (4%)	1.53	0.39

Unless otherwise indicated, data are the number of patients,  $\beta$ = unstandardized regression coefficient.

\**p* value below 0.05 (i.e., candidate predictor)

the resting pressure and squeeze pressure [inadequate (absent or decreased) or adequate (normal)] of the anal sphincter complex, as well as the presence of an anal sphincter defect.

### Anorectal functional tests

**Anal manometry** Anal manometry took place according to the solid-state or water-perfused technique without or with

sleeve [16]. The solid-state method or water-perfusion method without sleeve was performed by means of a pull-through technique. The catheter (Konigsberg Instrument, Pasadena, CA, USA; Medtronic, Skovlunde, Denmark; Dentsleeve Pty, Parkside, Australia) was inserted in the anal canal, and the (mean) maximal resting pressure (mmHg) was measured. Subsequently, the (mean) maximal squeeze pressure (mmHg) was determined by asking patients to squeeze three times during 10 s with 1-min intervals. An average maximal squeeze pressure was calculated. Further, the difference (mmHg) between anal and rectal pressure during straining and coughing was assessed.

*Pudendal nerve terminal motor-latency testing* Pudendal nerve terminal motor-latency was assessed at the right and the left sides using a St. Mark's Hospital electrode (Dantec; Skovlunde, Denmark) [20]. The pudendal nerve was stimulated on each side, and the time needed for the external anal sphincter to contract after stimulation was measured. Latencies longer than 2.2 ms were classified as pathologic.

*Anal sensitivity testing* Anal sensitivity testing was performed with a stimulation electrode (Dantec Keypoint, Skovlunde, Denmark) mounted on a Foley Ch 12 catheter [16]. The anal sensation was measured by positioning the electrode into the mid-anal canal and gradually increasing the current (up to a maximum of 20 mA), until patients reported some sensation. To determine the threshold for anal sensation (milliAmpere), the lowest of three following measurements was used.

*Rectal capacity measurement* The capacity measurement of the rectum was performed by using a balloon attached on a Foley Ch 14 catheter or a barostat [16]. The balloon catheter was introduced in the rectum and slowly inflated with air. The minimal rectal sensation perceived (sensory threshold), the volume associated with the initial urge to defecate (urge sensation) and the volume at which the patient experienced discomfort or pain and an intense desire to defecate (the maximal tolerated volume) were determined.

#### *Imaging techniques*

*Defecography.* Defecography was performed with contrast medium in rectum, small bowel, and, in women, the vagina [21, 22]. The dynamics of defecation were evaluated. The presence of an intussusception (intussusception grade one or two, intrarectal or intra-anal circular invagination of the proximal rectal wall during defecation), anterior rectocele (outward bulge of the anterior rectal wall), enterocele (prolapse of the small bowel into the rectogenital space), sigmoidocele (prolapse of the sigmoid colon into the

rectogenital space), or peritoneocele (prolapse of peritoneal fat or fluid into the rectogenital space) was assessed [21, 22].

*Endoanal sonography.* Endoanal sonography was performed with an ultrasound scanner (Bruel and Kjaer, Gentofte, Denmark; Multiview Aloka, Tokyo, Japan) with radial endoscopic probe and a 7.5- or 10-MHz transducer [23, 24]. The endoscopic probe was introduced into the anus to the level of the anorectal verge and slowly withdrawn. The presence of an internal and/or external anal sphincter defect was assessed. A defect of the internal or external anal sphincter was defined by a discontinuity of the muscle ring and/or characterized by loss of the normal architecture, with an area of amorphous texture that usually has low reflectiveness [23, 24].

*Endoanal magnetic resonance imaging.* Endoanal magnetic resonance (MR) imaging was performed at a 1.0- or 1.5-T MR unit (Philips Gyroscan ACS-NT, Philips Medical Systems, Best, the Netherlands; General Electric Horizon Echospeed, General Electric, Milwaukee, WI, USA) with a dedicated endoanal coil [23–25]. The endoanal coil was inserted in the anal canal, and the presence of defects of the internal and external anal sphincter was assessed, as was the presence of internal and external anal sphincter atrophy. A defect of the internal or external anal sphincter was defined as a discontinuity of the muscle and/or a hypointense deformation of the normal pattern of the muscle layer due to replacement of muscle cells by fibrous tissue [25]. External anal sphincter atrophy was defined as diffuse thinning of the muscle and/or replacement of muscle fibers by fat and internal anal sphincter atrophy as diffuse muscle thinning (<2 mm) [25].

#### *Pelvic-floor rehabilitation*

Pelvic-floor rehabilitation was administered by specialized pelvic physiotherapists according to a standardized protocol, which was compounded by clinicians and physiotherapists specialized in the field of pelvic-floor disorders. Participating physiotherapists were uniformly trained and instructed to perform the treatment protocol adequately. Patients underwent weekly 35-min sessions for 9 weeks. During the sessions, physiotherapists obtained data by performing digital rectal examination, rectal balloon training, and electromyography. Treatment targets and program were formulated based on these data. The pelvic-floor rehabilitation program comprised rectal balloon training, electrical stimulation, and/or electromyographic feedback. Electrical stimulation was offered only to patients with a poorly functioning external anal sphincter and/or puborectal muscle (Oxford score <3). The Oxford score reflects the strength of the puborectal muscles and external anal sphincter muscle and ranges from 0 (no muscle contraction)

to 5 (strong contraction) [26, 27]. Rectal balloon training was offered to all patients. Patients with an insensitive or hypersensitive rectum were respectively taught to perceive smaller or larger volumes of distension. Electromyographic feedback was offered to all patients with an average functioning external anal sphincter and/or puborectal muscle (Oxford score  $\geq 3$ ). Contraction capacities including duration, relaxation, timing, and coordination of the pelvic-floor muscles were trained. An extensive explanation and description of the pelvic-floor rehabilitation program and specific treatment targets have been reported elsewhere [12]. Outcome of pelvic-floor rehabilitation was assessed 3 months after completing the pelvic-floor rehabilitation program, using the Vaizey score.

### Statistical analysis

This study aimed to identify elements from patient's medical history, physical examination, anorectal functional tests, and imaging tests that could predict the Vaizey score after treatment. First, the assumption of linearity between the continuous variables and the change in Vaizey score was studied, using visual inspection and spline functions. If necessary, the continuous variables were transformed to better approach linearity. Then linear regression analyses of the posttreatment Vaizey score were used to identify candidate predictor variables, using the baseline Vaizey score as a covariate in all of the models. Since the aim of this analysis is prediction, a  $p$  value of 0.05 was chosen to select candidate predictors [28].

Subsequently, multivariable linear regression analysis with a stepwise backwards selection procedure was used to construct prediction models for the posttreatment Vaizey score. The initial prediction model (model 1) included elements from medical history only. Subsequently, to calculate the added value of elements derived from tests above the variables identified from medical history, different models were built. Separate models calculated the added value of the candidate predictors derived from physical examination, anorectal functional tests, and imaging techniques, each time using a stepwise backwards selection procedure ( $p < 0.05$ ).

A final model was built combining both the predictors from medical history and the predictors from all additional tests. The total proportion explained variance ( $R^2$ ) explained by this final model was examined. The  $R^2$  takes value in the 0 to 1 range, with values closer to 1 indicating a better fit.

## Results

### Patients

In total, 287 patients were included. Thirty-seven patients (13%) dropped out before or during the pelvic-floor

rehabilitation program, and baseline and follow-up Vaizey scores were available for 250 patients (87%). Their mean age was 59 years ( $SD \pm 13$ ); 228 (91%) were female and 22 (9%) were male. The median duration of fecal incontinence was 5 years (interquartile range 2 to 10). The mean Vaizey incontinence score at baseline was 18.3 ( $SD \pm 3$ ). Mean Vaizey score after pelvic-floor rehabilitation was 15.0 ( $SD \pm 5$ ), an average reduction of 3.2 points (95% CI,  $-2.6$  to  $-3.9$ ;  $p < 0.001$ ).

### Candidate predictors

Baseline characteristics obtained from medical history, physical examination, anorectal functional tests, and imaging techniques are summarized in Tables 1 and 2. None of the variables appeared to have a nonlinear relation with the posttreatment Vaizey score.

The results from the regression analyses to identify candidate predictor variables are shown in Tables 1 and 2. Higher baseline Vaizey scores were significantly associated with higher posttreatment Vaizey scores, i.e., a worse outcome of pelvic-floor rehabilitation ( $p < 0.001$ ).

The following elements from medical history were also significantly associated ( $p < 0.05$ ) with worse treatment outcome: presence of passive incontinence, thin stool consistency, and primary repair of a rupture after vaginal delivery at childbed. No element from medical history could be found that significantly associated with a better treatment outcome (Table 1).

Perineal and/or perianal scar tissue was the only candidate predictor identified from physical examination (Table 2). This variable was associated with a poorer treatment outcome. Of the anorectal functional test results, only a higher resting pressure and maximal squeeze pressure at anal manometry were predictive of a positive outcome (Table 2). Data obtained at defecography, endoanal MR imaging, or endoanal sonography were not significantly associated with the posttreatment Vaizey score (Table 2).

### Multivariable analyses of response to treatment

After identifying predictor variables, we investigated their pattern of missingness. Data were complete for almost 96% data points, and we were able to complete the data set using multiple imputation based on correlations.

The initial multivariable model included all candidate predictors identified at medical history. All variables appeared to be independent predictors for the posttreatment Vaizey score and therefore remained in the model. The final model (model 1 at Table 3) had a total  $R^2$  of 0.18.

In the second multivariable analysis, we added the candidate predictor (perineal and/or perianal scar tissue)



**Table 2** Association between candidate predictors from additional tests and posttreatment Vaizey score after adjustment for baseline Vaizey score

Additional tests	Value	$\beta$	$p$
<b>Physical examination</b>			
Squeeze pressure (inadequate)	208 (88%)	1.34	0.19
Resting pressure (inadequate)	166 (70%)	0.03	0.97
Perineal and/or perianal scar tissue*	138 (59%)	1.5	0.03*
Defect anal sphincter complex	80 (34%)	1.05	0.14
<b>Anorectal functional tests</b>			
Resting pressure, mmHg ( $\pm$ SD)*	49 ( $\pm$ 23)	-0.03	0.04*
Maximal squeeze pressure, mmHg ( $\pm$ SD)*	87 ( $\pm$ 40)	-0.02	0.006*
Difference anal-rectal pressure, coughing, mmHg ( $\pm$ SD)	20 ( $\pm$ 38)	0	0.78
Difference anal-rectal pressure, straining, mmHg ( $\pm$ SD)	8 ( $\pm$ 31)	0.01	0.54
Sensory threshold, ml ( $\pm$ SD)	49 ( $\pm$ 33)	0.01	0.34
Urge sensation, ml ( $\pm$ SD)	92 ( $\pm$ 49)	0	0.46
Maximal tolerable volume, ml ( $\pm$ SD)	156 ( $\pm$ 68)	0	0.95
Pathological pudendal nerve latency right side	83 (38%)	0.06	0.93
Pathological pudendal nerve latency left side	85 (39%)	-0.39	0.57
Threshold anal sensation, mAmp ( $\pm$ SD)	7.6 ( $\pm$ 6)	0.01	0.88
<b>Defecography</b>			
Presence of anterior rectocele	52 (27%)	-0.3	0.71
Presence of entero-, sigmo-, or peritoneocele	39 (21%)	0.21	0.82
Presence of intussusception	74 (39%)	0.68	0.35
<b>Endoanal sonography</b>			
Presence of EAS defect	136 (58%)	0.32	0.63
Presence of IAS defect	68 (29%)	0	0.99
<b>Endoanal MR imaging</b>			
Presence of EAS defect	88 (46%)	1.1	0.14
Presence of IAS defect	71 (37%)	0.46	0.57
Presence of EAS atrophy	127 (66%)	-0.06	0.95
Presence of IAS atrophy	34 (18%)	1.39	0.16

Unless otherwise indicated, data are the number of patients,  $\beta$ =unstandardized regression coefficient.

EAS External anal sphincter, IAS internal anal sphincter

\* $p$  value below 0.05 (i.e., candidate predictor)

from physical examination to model 1 and applied a backwards elimination strategy. In addition to the variables from medical history, perineal and/or perianal scar tissue remained significantly associated with the Vaizey score after therapy. Adding perineal and/or perianal scar tissue marginally increased the total  $R^2$  to 0.19 (model 2 in Table 2;  $p=0.16$ ).

In a similar way, we looked at the candidate predictors from anal manometry. Only maximal squeeze pressure was significantly associated with the posttreatment Vaizey score

in this multivariable model and increased the  $R^2$  to 0.20 (model 3 in Table 2;  $p=0.03$ ).

The final multivariable model (model 4) contained, in addition to the Vaizey score at baseline, three patient characteristics (passive incontinence, thin stool consistency, and primary repair of a rupture after vaginal delivery at childbed) and two test variables (perineal and/or perianal scar tissue and maximal squeeze pressure). A higher Vaizey score at baseline, passive incontinence, thin stool consistency, primary repair of a rupture after vaginal delivery at childbed, and perineal and/or perianal scar tissue were associated with poor response, whereas a higher maximal squeeze pressure was related with better response. This complete model resulted in a  $R^2$  of 0.20 (model 4 in Table 3;  $p=0.05$ ).

Figure 1 shows the association between the predicted Vaizey score based on the complete model (model 4) and the observed posttreatment Vaizey score. On basis of the final model, it is impossible to accurately determine the posttreatment score of an individual patient. Particularly in patients with a low observed Vaizey score after treatment, the model tends to overestimate the predicted posttreatment Vaizey score.

## Discussion

This study demonstrates that tests have a limited role in predicting outcome of pelvic-floor rehabilitation in patients with fecal incontinence due to mixed etiologies. We found a number of elements from medical history to be associated with the posttreatment Vaizey score, including presence of passive incontinence, thin stool consistency, primary repair of a rupture after vaginal delivery at childbed, and baseline Vaizey score. Adding test parameters from physical examination (perineal and/or perianal scar tissue) and anal manometry (maximal squeeze pressure) marginally improved the predictive value to outcome, but overall, no accurate assessment of the posttreatment Vaizey score in an individual patient was possible, especially not in those patients with a low observed Vaizey score.

A number of potential limitations should be taken into account. Some patients groups were excluded for this study as in these patients a specific disorder was held responsible for the fecal incontinence complaints. These patients needed treatment for that disorder and would not a priori be eligible for pelvic-floor rehabilitation. Consequently, the study population of this study does not represent the full spectrum of fecal incontinence complaints and, therefore, the observed results cannot be unconditionally generalized to all patients with fecal incontinence.

The majority of participating patients was female (91%), an imbalance that is not due to a form of selection bias but

**Table 3** Several prediction models for the posttreatment Vaizey score

	Model 1	Model 2	Model 3	Model 4
Predictor elements	Medical history	Medical history Physical examination	Medical history Anal manometry	Medical history Physical examination Anal manometry
$R^2$ of model	0.18	0.19	0.20	0.20
Significance of change <sup>a</sup>		0.05	0.03*	0.05*

Candidate predictor resting pressure dropped out in the multivariate analysis due to  $p$  values above 0.05.

*Medical history* Vaizey score at baseline, presence of passive incontinence, thin stool consistency, and primary rupture after vaginal delivery repaired at childbed; *Physical examination* perineal and/or perianal scar tissue; *Anal manometry* maximal squeeze pressure

<sup>a</sup>Compared to model 1 (only predictors from medical history)

\*Significant difference compared to model 1 ( $p < 0.05$ )

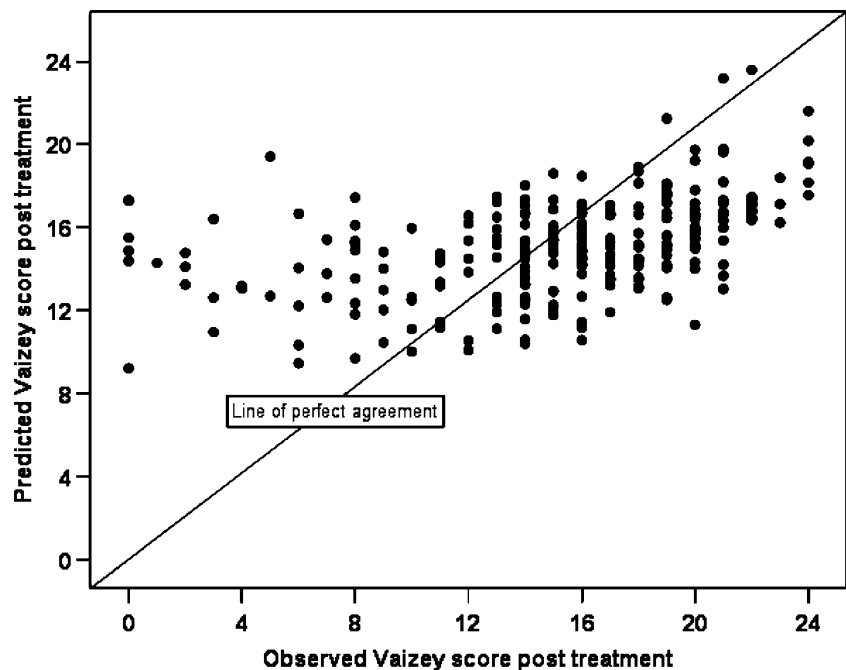
is inherent to the etiology of fecal incontinence, as obstetric damage of the anal sphincter complex proved to be a major cause of fecal incontinence [29]. To assess the outcome of pelvic-floor rehabilitation, we used the Vaizey score, as this score is a widely used score containing important incontinence-specific items like frequency and type of fecal incontinence, alteration in life style, and pad and/or medication use. The Vaizey score has proved to be reproducible, and previous studies have demonstrated an association between this scoring system, physicians' clinical impression, and patients' subjective perception of relief [18, 30, 31].

The additional tests, although performed according to standard procedures, were performed by different specialized physicians or technicians, and the equipment used was not identical for all tests. This goes hand in hand with the multicenter design of our study, reflecting daily clinical practice. Due to the design of our study, the observed

changes in Vaizey score after treatment cannot exclusively be attributed to the pelvic-floor rehabilitation program, as this study was not randomized with a parallel control group receiving no treatment. The cohort study design was selected as we wanted to evaluate the value of tests in predicting the outcome of pelvic-floor rehabilitation in a large group of patients with fecal incontinence due to mixed etiologies, as worldwide this was, until now, not well established [13, 14, 17].

In contrast to other studies [32, 33], this study found that symptom severity of fecal incontinence could predict outcome after pelvic-floor rehabilitation to some extent. The observation that patients with a higher Vaizey score, indicating more severe fecal incontinence, were less likely to respond to pelvic-floor rehabilitation could be explained by the fact that, in these patients, the underlying pathophysiology will be more extensive than in patients with a lower score. We did not find an association between

**Fig. 1** Association between the predicted posttreatment Vaizey score based on medical history and additional test and the observed posttreatment Vaizey score



outcome and age or gender, while another study had reported that patients under age 55 had a negative response to treatment [34].

The fact that thin stool consistency was related to poor outcome confirms the importance of stool consistency, additionally to normal anorectal function, in maintaining continence [14, 15]. Previous studies have reported that pelvic-floor rehabilitation was less effective in patients with neurogenic fecal incontinence [35] and more effective in patients with fecal incontinence due to anal surgery or trauma [33], but we found only in patients with a primary repair of a rupture at childbed after vaginal delivery and scar tissue of the perineum and/or perianal area a worse outcome of pelvic-floor rehabilitation. The sensation of incomplete rectal evacuation might, for instance, be related to the presence of an anterior rectocele or irritable bowel syndrome, but neither information from medical history, defecography nor from rectal capacity measurement was related to outcome. This is in contrast with other studies, which reported improved outcomes in patients with the ability to sense rectal distension [36, 37].

Unlike previous studies [32, 37, 38], this study showed that baseline maximal squeeze pressure was related to outcome. Pelvic-floor rehabilitation aims to reinforce the external anal sphincter, and its effects may be more pronounced in patients with a reasonable pretreatment maximal squeeze pressure, reflecting external anal sphincter function.

The internal anal sphincter is the main factor responsible for maintaining continence at rest, and its function is not trained by pelvic-floor rehabilitation. This might explain the worse outcome in patients with passive incontinence, which is thought to be related to internal anal sphincter dysfunction [39].

Norton and Kamm [8] found better results after pelvic-floor rehabilitation in patients with an intact anal sphincter complex, but we demonstrated, as did earlier studies [32, 40], that the presence of an internal and/or external anal sphincter defect was not important for predicting outcome following pelvic-floor rehabilitation, just like the presence of internal and/or external anal sphincter atrophy.

Patient coping strategies may play a role in improving continence after treatment, but at the time this study was initiated, we did not have a well-validated questionnaire for the assessment of coping strategies available.

Diagnostic tests are used to gain information about the underlying pathophysiology of fecal incontinence [4, 15, 16]. Fecal incontinence is a multifactorial disorder, and results of different tests should be combined to achieve a clear impression about the etiology. Substantial variation exists between institutions and clinicians in the interpretation of test results and their management consequences

[17]. Although this study has shown that some elements from medical history and additional test variables were predictive to response after pelvic-floor rehabilitation, the overall predictive value of the multivariable model was limited. On basis of additional tests to assess fecal incontinence, patients cannot be informed on the likely outcome of pelvic-floor rehabilitation. This suggests that additional tests are not strictly essential before referring patients for pelvic-floor rehabilitation.

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