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Tools for fecal incontinence assessment: lessons for inflammatory bowel disease trials based on a systematic review

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Abstract

Background: Fecal incontinence is a disabling condition affecting up to 20% of women.
Objective: We investigated fecal incontinence assessment in both inflammatory bowel disease and non-inflammatory bowel disease patients to propose a diagnostic approach for inflammatory bowel disease trials.
Methods: We searched on Pubmed, Embase and Cochrane Library for all studies on adult inflammatory bowel disease and non-inflammatory bowel disease patients reporting data on fecal incontinence assessment from January 2009 to December 2019.
Results: In total, 328 studies were included; 306 studies enrolled non-inflammatory bowel disease patients and 22 studies enrolled inflammatory bowel disease patients. In non-inflammatory bowel disease trials the most used tools were the Wexner score, fecal incontinence quality of life questionnaire, Vaizey score and fecal incontinence severity index (in 187, 91, 62 and 33 studies). Anal manometry was adopted in 41.2% and endoanal ultrasonography in 34.0% of the studies. In 142 studies (46.4%) fecal incontinence evaluation was performed with a single instrument, while in 64 (20.9%) and 100 (32.7%) studies two or more instruments were used. In inflammatory bowel disease studies the Wexner score, Vaizey score and inflammatory bowel disease quality of life questionnaire were the most commonly adopted tools (in five (22.7%), five (22.7%) and four (18.2%) studies). Anal manometry and endoanal ultrasonography were performed in 45.4% and 18.2% of the studies.
Conclusion: Based on prior validation and experience, we propose to use the Wexner score as the first step for fecal incontinence assessment in inflammatory bowel disease trials. Anal manometry and/or endoanal ultrasonography should be taken into account in the case of positive questionnaires.

Keywords

Fecal incontinence, assessment, inflammatory bowel disease, Wexner score, clinical trial

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Introduction

Fecal incontinence (FI) is defined as the involuntary loss of liquid or solid stool.[1] It represents not only an embarrassing and humiliating symptom for patients, but also a serious social problem impacting considerably on everyday life.[2] FI was traditionally thought to affect about 2–10% of the general population and to increase in incidence with age.[3,4] However, more recent population-based studies[5–7] have revealed an incidence of 18.8% in adult women in the USA. Although 18.8% might seem a high prevalence, in patients with inflammatory bowel disease (IBD) FI occurs in an even

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higher percentage of patients.[8] A study by the British National Crohn's and Colitis UK Organization[8] including over 3000 subjects showed that 74% of IBD patients reported at least one episode of FI in their life. The increased rate of FI in IBD patients is probably due to predisposing factors such as perianal disease, invasive perianal surgical approach, liquid stools and secretory diarrhoea caused by bile acid malabsorption.[9–12] The pathophysiology of FI is very complex and may depend on different structures, including pelvic floor, anal sphincter muscles and both the voluntary and autonomous nervous system.[13] Furthermore, the diagnosis of FI is not easy as patients are reluctant to report this embarrassing symptom, treating physicians often do not investigate it, and a clear and validated approach to diagnose it is lacking.[5–7,14] A combination of different tests may be necessary to diagnose FI and to attribute the incontinence to a specific aetiology. Available options include self-reported questionnaires, anorectal manometry, electromyography (EMG), defecography, endoanal ultrasonography, magnetic resonance imaging (MRI), computed tomography (CT) and pudendal nerve terminal motor latency (PNTML) assessment.[15] Tools such as the validated Wexner score,[15] Vaizey score[16] and fecal incontinence quality of life (FIQL) questionnaire[17] assess FI measuring severity and impact on quality of life. Anorectal manometry allows us to measure resting and squeeze pressure, duration of the voluntary contraction and length of the anal canal.[18] Endoanal ultrasonography is recommended to investigate sphincteric lesions as a preoperative assessment, while physiology tests and other imaging procedures provide additional anatomical and functional data.[18] A correct FI evaluation is essential to obtain an early diagnosis of disease and to ensure a rapid treatment. Our aim was to investigate FI assessment in both patients with or without IBD in order to clarify the diagnostic approach for this disabling condition and to propose an algorithm for IBD trials.

Methods

This systematic review has been developed according to the guidance specified in the Cochrane Handbook and the preferred reporting items for systematic reviews and meta-analyses (PRISMA) guidelines.[19,20]

Search strategy

The review consists of two parts: FI assessment in non-IBD patients and FI assessment in IBD patients. We searched for published studies on Pubmed, Embase and the Cochrane Library starting from January 2009 to December 2019 in order to investigate the literature evidence of the past 10 years. The following MESH terms alone or matched to 'IBD', 'inflammatory bowel disease', 'UC', 'ulcerative colitis', 'CD' and 'Crohn's disease' were used: 'fecal incontinence', 'anal incontinence', 'assessment', 'evaluation', 'diagnosis', 'tool' and 'investigation'. All studies on adult patients reporting data on FI assessment were included in our review. Reviews, meta-analyses, guidelines and editorials were excluded. Our search focused on full-text articles published in English, but relevant abstracts were evaluated. The careful analysis of the reference lists of the included studies allowed us to identify additional studies.

Selection process and data extraction

Two authors (FD and CG) independently screened all titles and removed duplicates and non-fitting papers. Subsequently the articles that met the inclusion criteria were evaluated by two authors (FD and CG) to define their eligibility. Any disagreement between investigators was discussed with the co-authors (SD and LPB) until consensus was reached. Two reviewers (FD and CG) extracted the following data from each study: name of the first author, publication year, study design, field of research (e.g. gastroenterology, surgery, gynaecology, etc.), patient cohort (number, sex, mean age, type of bowel disease) and FI assessment (diagnostic tools, used investigations). In the case of non-specified data, we indicated it as 'NS'.

Quality of studies

The Newcastle–Ottawa Scale (NOS) score[21] was used to measure the quality of non-randomised studies, while in randomised clinical trials the Jadad score[22] was adopted. High quality studies were defined as NOS score of 6 or greater or Jadad score of 3 or greater, respectively. Two authors (FD and CG) graded the studies independently and disagreements were discussed with a third author until their resolution.

Results

Search results

The flow chart of the search process is shown in Figure 1. Patient demographics and main characteristics of non-IBD and IBD studies are reported in Tables 1 and 2, respectively. A total of 1727 articles were investigated (Pubmed: 1022; Embase: 426; Cochrane Library: 279). Three hundred and fifty-five papers were eligible for inclusion after the elimination of duplicates and screening of all titles. After careful evaluation of full-text papers 27 studies were excluded: 15 studies[23–37] did not evaluate FI assessment, six

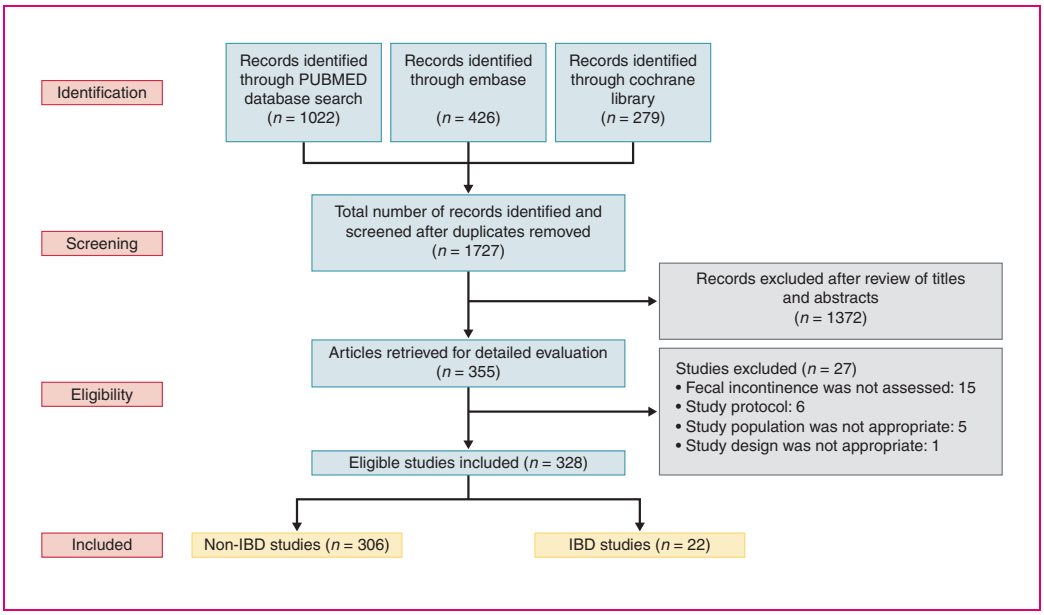

Figure 1. Flow chart of the search process.

manuscripts[38–43] were just protocols, five were paediatric studies,[44–48] and one trial[49] had an inappropriate study design. Finally, 328 studies were included in our review: 306 studies[50–355] on non-IBD patients and 22 studies on IBD patients.[8,356–376] Overall, 102,460 patients were enrolled in non-IBD studies (66.7% women) and 8289 in IBD studies (63.9% women), with the number of patients per study ranging from six to 47,714. Among non-IBD trials there were 137 prospective cohort studies,[48,50–53,58,59,61,62,64,68–72,74–76,79–81,93,103,104,107,110–113,119,120,124–126,128,131,135,137,142–145,149,151,153,157–163,166,168,169,171–174,176–182,187,190,192,197,198,202,204,207,211–214,216,218,219,221,222,224,225,231,234,235,238,240,242,244,245,247–251,253,259,261–263,267,269,273,275,277,280,281,285,288,290–293,298–300,303,304,306,308,312,315,317,323,325,327–331,333,340,343,346] 78 retrospective cohort studies,[51,57,69,75,84,88,90–93,98,99,107,108,110,116,117,120,124,129,131,134,138,140,141,148,150,152,154,158,167,169,177,185–188,190,193,198,201,205,210,211,219,229,230,239,243,245,254,256,258,259,262,274,276,278,280,281,285,286,288,289, 291, 299,311,315,337,339–341,344, 346,347,349,350, 355] 76 randomised clinical trials,[58,65,67,68,79,80,85–87,96,97,100–104,111,118,119,123,125,132,135,136,142,143,156,157,166,172,191,195–197,203,207,212,217,225,228,231,232,234,235,238, 241,248,257,260,267,268,270,272,273,284,296–298,303,304,307,309,312,321–324,328,334,336,338,343,351–354] nine cross-sectional[56,59,62,89,222,266,316,318,320] and six case–control studies.[94,149,202,208,313,326] In IBD trials, instead, there were 11 retrospective cohort studies,[8,359,360,362,365–368,371,372,374] 10 prospective cohort studies[356–358,361,363,364,370,373,375,376] and one cross-sectional study.[369] Overall, studies on FI involved 16 different research areas: the most frequent were surgery, gynaecology and gastroenterology (179,[51,52,54,59–64,66–73,75,80,81,83,84,88,89,97–99,105,106,109,110,114,115,120,124–127,129–132,135–139,141,148,154–156,160–163,165–167,170,174–181,183,184,188,193–196,198–208,210–215,219,223–229,234–238,240–245,247–253,256,258–260,262–264,266,267,269–273,275,276,278,279,282,284–286,292,295–297,299,302–308,310,311,314–316,319,321,324,327–330,332–336,340,341,344,345,349,350,352–355] 45,[53,56,79,93,112,113,116–118,121,133,140,142–144,146,147,149,151–153,169,171,173,182,186,187,222,254,255,283,287–291,293,298,312, 313,317,318,325,331,342] and 32 studies,[50,65,76–78,82,90–92,94–96,103,107,122,123,172,216–218,257,277,280,281,301,309,338,343,347,348,362,376] respectively). Overall, 172/252 non-randomised studies (68.2%) had a NOS score of 6 or greater and 51/76 randomised studies (67.1%) had a Jadad score of 3 or greater (see Supplementary Tables 1 and 2).

Fecal incontinence assessment in non-IBD patients

FI was assessed using specific questionnaires in all studies, except for four trials.[168,213,274,280] Twenty-nine different questionnaires were applied: the most widely adopted were the Wexner score (187 studies),[50,52,54,55,59,61,63,66,69–71,73–83,86–92,97–99,101,103–107,110,114,116,117,120–123,126–128,130,131,133,135–139,141,144,146–156,160,164–167,169,170,174,177–179,182,194–203,205–208,210–212,214,215,217–220,223–226,229,234–239,241–245,247–253,256,259,261,264,265,270–273,276,278,279,281,284–287,289,291–296,298–306,308–311,314,315,319,321,323–326,328,330,333–336,339–341,347,349,350,353,354]

FIQL questionnaire (91 studies),[50,62,67,73–75,79,84–88,100,101,104,106,109,115,121,123–125,127–129,131,134–136,139,147,151,152,155,157,158,161,165,166,170,172,179,181,183,190,208,209,212,214,217,218,235,240–242,249,255–257,260–263,265,269,270,273,279,283,288,292–297,302,303,309,311,314,319,321,322,324,333,334,338,349,350,355

Table 1. Fecal incontinence assessment in non-IBD patients.

Study	Research area	Study design	no. of pts	F (*n*)	Mean age	FI aetiology	Tools	Anal manometry	Endoanal ultrasound	Defecography	Other
Eléouet et al., 2010 [50]	Gastroenterology	Prospective cohort study	32	30	61	Structural	Wexner score FIQL	3-lumen, water perfused catheter (R3B and PIP4-4, Mui Scientific, Mississauga, Ontario, Canada)	/	/	/
Göttgens et al., 2015 [51]	Surgery	Retrospective cohort study	537	158	45.5	Structural	Vaizey score	/	/	/	/
Köhler et al., 2012 [52]	Surgery	Prospective cohort study	80	69	NS	Structural	Wexner score	/	/	ns	Dynamic MRI
Naidoo et al., 2018 [53]	Gynaecology	Prospective cohort study	100	100	NS	Mixed	Non-validated questionnaire	(Stryker, Kalamazoo, Michigan)	InNovaSound USB© endocavity ultrasound probe. This is a 360° rotating 7.5 MHz endoprobe.	/	/
Pena Ros et al., 2015 [54]	Surgery	Prospective cohort study	55	44	58.6	Structural	Wexner score	/	/	/	/
Valles et al., 2009 [55]	Neurology	Prospective cohort study	54	22	43	Neurogenic	Wexner score	Measurements were performed using three different catheters	/	/	/
Taithongchai et al., 2019 [56]	Gynaecology	Cross-sectional study	250	250	31	Mixed	modified Vaizey score	/	/	/	/
Szucs et al., 2012 [57]	Urology	Retrospective cohort study	76	30	61	Structural	EORTC QLQ	Medtronic rectal manometer	/	/	/
Bø et al., 2010 [58]	Physiotherapy	Prospective randomised clinical trial	105	105	31	/	Non-validated questionnaire	/	/	/	/
Parés et al., 2015 [59]	Surgery	Cross sectional study	228	228	31	/	Wexner score	/	/	/	/
Davé et al., 2016 [60]	Surgery	Prospective cohort study	268	268	32	/	FISI	/	/	/	/
Lopez-Delgado et al., 2014 [61]	Surgery	Prospective cohort study	24	19	62	Mixed	Wexner score	8 channel recorder (Griffon, Albyn Medical, Cordovilla-Navarra, Spain)	/	/	/
Pares et al., 2011 [62]	Surgery	Cross sectional study	518	332	60	/	Vaizey score FIQL	/	/	/	/
Worsøe et al., 2012 [63]	Surgery	Prospective cohort study	9	9	60	Idiopathic	Vaizey score Wexner score	/	/	/	/
Waniczek et al., 2012 [64]	Surgery	Prospective cohort study	16	14	76.3	Structural	Miller's score	/	/	/	/
Sjodahl et al., 2014 [65]	Gastroenterology	Prospective randomised clinical trial	57	57	58	/	Non-validated questionnaire	(Hallböök & Sjödahl)	3D-EAUS Falcon 2101 ELX scanner (B-K Medical, Herlev, Denmark) 13 MHz probe	/	/
Petersen et al., 2016 [66]	Surgery	Prospective cohort study	110	71	59.7	Structural	Wexner score	/	/	/	/
Horrocks et al., 2015 [67]	Surgery	Prospective randomised clinical trial	227	104	58	Mixed	Vaizey score FIQL	/	/	/	/
Brown et al., 2016 [68]	Surgery	Prospective randomised clinical trial	370	153	49	Structural	Vaizey score	/	/	/	/
Abbas et al., 2012 [69]	Surgery	Retrospective cohort study	27	22	64	Mixed	Wexner score	/	/	/	/
Abramowitz et al., 2013 [70]	Surgery	Prospective cohort study	264	140	45.2	Structural	Wexner score Vaizey score	/	/	/	/

(continued)

Table 1. Continued.

Study	Research area	Study design	no. of pts	F (*n*)	Mean age	FI aetiology	Tools	Anal manometry	Endoanal ultrasound	Defecography	Other
Abramowitz et al., 2016 [71]	Surgery	Prospective cohort study	195	51	45.5	Structural	Wexner score Vaizey score	/	/	/	/
Adusumilli et al., 2013 [72]	Surgery	Prospective cohort study	120	/	60	/	FISI GIQLI	water-perfused 9-lumen vector manometry catheter (MED 2280; Mediplus, High Wycombe, UK), and 8 channel transducer	(B&K Medical, Naerum, Denmark) 10-MHz probe	oral 100 ml barium sulphate paste and 10 ml Gastrografin contrast. 100 ml of rectal barium paste	/
Aigner et al., 2009 [73]	Surgery	Prospective cohort study	11	11	66	Idiopathic	Wexner score FIQL	(ACP Manometer Reha Medi, Ganderkesee, Germany).	(Pro Focus 2202, B-K Medical, Herlev, Denmark) 6–16 MHz probe	/	/
Ait Said et al., 2017 [74]	Urology	Prospective cohort study	116	83	47.6	Structural	Wexner score FIQL	/	/	/	/
Al Asari et al., 2014 [75]	Surgery	Retrospective cohort study	57	50	61	/	Wexner score FIQL	/	/	/	PNE (Medtronic, Minneapolis, MN, USA)
Albuquerque et al., 2016 [76]	Gastroenterology	Prospective cohort study	23	16	56	Structural	Wexner score	/	Hitachi-Aloka Medical Ltd., Tokyo, Japan ultrasound scanner	/	/
Allgayer et al., 2010 [77]	Gastroenterology	Prospective cohort study	50	20	58..3	Mixed	Modified Wexner score	ns	(EUB 8500 and 900 HV; Hitachi, Wiesbaden, Germany) 5–10 MHz probe	/	Endoscopy
Allgayer et al., 2012 [78]	Gastroenterology	Prospective cohort study	90	39	59	Structural	Modified Wexner score	ns	(EUB 8500 and 900 HV; Hitachi, Wiesbaden, Germany) 5–10 MHz probe	/	Endoscopy
Altman et al., 2016 [79]	Gynaecology	Prospective randomised clinical trial	30	30	61.8	/	Wexner score FIQL	/	/	/	/
Altomare et al., 2011 [80]	Surgery	Prospective randomised clinical trial	64	/	50.5	Structural	Wexner score	ns	ns	/	/
Altomare et al., 2015 [81]	Surgery	Prospective cohort study	407	/	/	/	Wexner score Vaizey score	/	/	/	/
Andrianjafy et al., 2019 [82]	Gastroenterology	Prospective cohort study	1477	1182	54	Neurogenic	Wexner score	3DHRAM probe (Mano-Scan 3D; Sierra Scientific Instruments, Los Angeles, CA, USA)	/	/	/
Arroyo et al., 2014 [83]	Surgery	Prospective cohort study	16	15	56.5	Structural	Wexner score	Albyn medical, Palex, with 8 channels	Pro Focus, Ultrasound Scanner Class I, Type B. Ref: 2002 SN1880355, BK Medical, model. Herlev, Dinamarca.	/	/
Aytac et al., 2015 [84]	Surgery	Retrospective cohort study	217	95	55	Structural	FISI FIQL	/	/	/	/
Barak et al., 2019 [85]	Neurology	Prospective randomised clinical trial	19	3	42.6	Neurogenic	FISI FIQL	MCOMPASS (Medspira, Minneapolis, MN)	/	/	/
Bartlett et al., 2011 [86]	Physiotherapy	Prospective randomised clinical trial	72	53	62.1	/	Wexner score FIQL	ns	ns	/	/
Bartlett et al., 2015 [87]	Physiotherapy	Prospective randomised clinical trial	75	63	61.1	/	Wexner score FIQL	/	/	/	/
Barussaud et al., 2013 [88]	Surgery	Retrospective cohort study	23	23	64	/	Wexner score FIQL	/	/	/	/

(continued)

Table 1. Continued.

Study	Research area	Study design	no. of pts	F (*n*)	Mean age	FI aetiology	Tools	Anal manometry	Endoanal ultrasound	Defecography	Other
Battersby et al., 2016 [89]	Surgery	Cross sectional study	462	184	70	Structural	Wexner score EORTC QLQ	/	/	/	/
Beer-Gabel et al., 2015 [90]	Gastroenterology	Retrospective cohort study	105	105	56	/	Wexner score	/	(B&K, Profocus Ultra View, Herlev, Denmark) 5–8 MHz probe	120 ml rectal barium paste	/
Benezech et al., 2014 [91]	Gastroenterology	Retrospective cohort study	19	19	53	/	Wexner score	3D High-Resolution Given Imaging probe	/	Rectal contrast (300 ml)	/
Benezech et al., 2015 [92]	Gastroenterology	Retrospective cohort study	206	187	54	/	Wexner score	3D High-Resolution Given Imaging probe ManoView (Given Imaging, Yokneam, Israel)	(model EUP-U533, Hitachi, Tokyo, Japan) 7-MHz probe	/	/
Berretta et al., 2016 [93]	Gynaecology	Retrospective cohort study	22	22	65	Structural	FISI	/	/	/	/
Bharucha et al., 2010 [94]	Gastroenterology	Case control study	176	176	58	/	FICA	/	/	/	/
Bharucha et al., 2011 [95]	Gastroenterology	Prospective cohort study	32	/	/	/	FICA	ns	/	/	/
Bharucha et al., 2014 [96]	Gastroenterology	Prospective randomised clinical trial	43	43	58	/	FICA	(Sierra Scientific Instruments, Los Angeles, CA)	/	/	Endoanal MRI
Biondo et al., 2013 [97]	Surgery	Prospective randomised clinical trial	106	27	64	Structural	Wexner score	/	/	/	/
Boenicke et al., 2012 [98]	Surgery	Retrospective cohort study	181	/	64	Structural	Wexner score	ns	/	ns	Endoscopy CT scan
Bokhari et al., 2009 [99]	Surgery	Retrospective cohort study	128	37	45	Structural	Wexner score	/	/	/	/
Bols et al., 2012 [100]	Physiotherapy	Prospective randomised clinical trial	80	72	59.3	/	Vaizey score FIQL	/	/	/	/
Bols et al., 2013 [101]	Physiotherapy	Prospective randomised clinical trial	80	72	59.3	/	Vaizey score Wexner score FIQL	/	/	/	/
Booth et al., 2013 [102]	Physiology	Prospective randomised clinical trial	30	24	84.2	/	ICIQ Bowel questions	/	/	/	/
Bouguen et al., 2014 [103]	Gastroenterology	Prospective randomised clinical trial	19	18	64.7	/	Wexner score	4-lumen, water-perfused catheter (R3B and PIP4-4; Mui Scientific, Mississauga, ON, Canada)	/	/	/
Boyer et al., 2018 [104]	Immunology	Prospective randomised clinical trial	24	24	52	Structural	Wexner score FIQL	ns	ns	/	PNTML Defeco-MRI
Boyle et al., 2009 [105]	Surgery	Prospective cohort study	15	15	53	Structural	Wexner score	ns	(Type 1846 probe with 10-MHz transducer, B-K Medical, Berkshire, UK)	ns	PNTML
Bridoux et al., 2010 [106]	Surgery	Prospective cohort study	6	3	56.6	Neurogenic	Wexner score FIQL	ns	/	/	/
Butt et al., 2015 [107]	Gastroenterology	Retrospective cohort study	10	10	54	Neurogenic	Wexner score	ns	/	/	/
Caremel et al., 2012 [108]	Urology	Retrospective cohort study	51	36	56.8	/	Non-validated questionnaire	/	/	/	/
Cauley et al., 2019 [109]	Surgery	Prospective cohort study	946	844	60	/			ns	ns	/

(continued)

Table 1. Continued.

Study	Research area	Study design	no. of pts	F (*n*)	Mean age	FI aetiology	Tools	Anal manometry	Endoanal ultrasound	Defecography	Other
							FISI FICA FIQL	(Duet software, Mediwatch USA, West Palm Beach, FL)			
Cerro et al., 2016 [110]	Surgery	Retrospective cohort study	95	95	33.8	Structural	Wexner score	/	3D diagnostic ultrasound system (type 2052, Ultraview-800; BK-Medical) 13 MHz probe	/	/
Chakraborty et al., 2016 [111]	Neurology	Prospective randomised clinical trial	36	36	56	/	Non-validated questionnaire	HD-ARM probe (Given Imaging, Yoqneam, Israel) HR-ARM catheter (Given Imaging, Los Angeles, CA, USA)	/	/	endoanal MRI
Chan et al., 2013 [112]	Gynaecology	Prospective cohort study	328	328	30.6	Structural	PFDI	/	/	/	/
Chan et al., 2014 [113]	Gynaecology	Prospective cohort study	328	328	30.6	Structural	PFDI PFIQ	/	GE Voluson 730 3D Ultrasound system (GE Medical Systems, Zipf, Austria) 4–8 MHz probe	/	/
Chen et al., 2015 [114]	Surgery	Prospective cohort study	46	42	48	/	Wexner score GIQLI	/	/	/	CT scan
Chew et al., 2011 [115]	Surgery	Prospective cohort study	17	13	67.2	Idiopathic	FISI FIQL	ns	ns	/	PNTML
Cichowski et al., 2013 [116]	Gynaecology	Retrospective cohort study	1115	1115	56	/	Wexner score	/	/	/	/
Cichowski et al., 2014 [117]	Gynaecology	Retrospective cohort study	1004	1004	58.5	/	Wexner score	/	/	/	/
Cichowski et al., 2015 [118]	Gynaecology	Prospective randomised clinical trial	90	90	58	/	FISI	/	/	/	/
Cohen-Zubary et al., 2015 [119]	Physiotherapy	Prospective randomised clinical trial	36	36	67.45	/	Vaizey score	/	/	/	/
Contin et al., 2013 [120]	Surgery	Retrospective cohort study	263	80	67	Structural	Wexner score	/	/	/	/
Cornelisse et al., 2016 [121]	Gynaecology	Prospective cohort study	335	335	/	Structural	Wexner score FIQL	/	/	/	/
Coura et al., 2016 [122]	Gastroenterology	Prospective cohort study	76	76	56.3	/	Wexner score	8-channel manometer (Dynamed, Procto Master Software, São Paulo, Brazil)	Pro-Focus 2052, 9-16 MHz, (B&K Medical, Herlev, Denmark).	/	/
Damon et al., 2014 [123]	Gastroenterology	Prospective randomised clinical trial	157	121	61	/	Wexner score FIQL	ns	/	/	/
Dehli et al., 2011 [124]	Surgery	Retrospective cohort study	76	73	54.5	/	Vaizey score FIQL	/	/	/	/
Dehli et al., 2013 [125]	Surgery	Prospective randomised clinical trial	126	117	57.5	/	Vaizey score FIQL	8 channel water-perfused catheter coupled to a computer (Medtronic, Skovlunde, Denmark)	3D anal ultrasound (B-K Medical, Gentofte, Denmark)	/	/
de la Portilla et al., 2009 [126]	Surgery	Prospective cohort study	16	11	59	/	Wexner score	/	/	/	/
	Surgery		7	6	55.6	Structural		(Laborie Medical, Belgium)		/	/

(continued)

Table 1. Continued.

Study	Research area	Study design	no. of pts	F (*n*)	Mean age	FI aetiology	Tools	Anal manometry	Endoanal ultrasound	Defecography	Other
de la Portilla et al., 2017 [127]		Prospective cohort study					Wexner score FIQL		3D-EAU using Pro Focus 2202s ultrasound with a B-K 2050 probe (B-K Medical, Herlev, Denmark)		
de Mello Portella et al., 2012 [128]	Urology	Prospective cohort study	190	190	54.3	Structural	Wexner score FIQL	/	/	/	/
Denoya et al., 2014 [129]	Surgery	Retrospective cohort study	40	/	53	Structural	FIQL	/	/	/	/
Didailler et al., 2018 [130]	Surgery	Prospective cohort study	25	6	62	Structural	Wexner score GIQLI	/	/	/	/
Digennaro et al., 2012 [131]	Surgery	Retrospective cohort study	60	/	65	Structural	Wexner score FIQL EORTC QLQ	/	/	/	/
Doeksen et al., 2011 [132]	Surgery	Prospective randomised clinical trial	107	34	66	/	COREFO EORTC QLQ	/	/	/	/
Drusany Starič et al., 2016 [133]	Gynaecology	Prospective cohort study	60	60	32	Structural	Wexner score	/	B&K Medical 2050 endoscopic probe (B&K Medical, Sandhoften, Denmark)	/	/
Dudding et al., 2011 [134]	Physiology	Retrospective cohort study	9	7	44	Structural	FIQL	ns	/	/	/
Duelund-Jakobsen et al., 2012 [135]	Surgery	Prospective randomised clinical trial	15	/	54.2	Mixed	FIQL Vaizey score Wexner score	/	/	/	/
Duelund-Jakobsen et al., 2013 [136]	Surgery	Prospective randomised clinical trial	19	18	59.5	Mixed	Wexner score FIQL Vaizey score	/	/	/	/
Duelund-Jakobsen et al., 2016 [137]	Surgery	Prospective cohort study	164	153	/	Mixed	Wexner score Vaizey score	/	/	/	/
Dumont et al., 2013 [138]	Surgery	Retrospective cohort study	36	11	60.5	Structural	EORTC QLQ Wexner score	/	/	/	/
El-Gazzaz et al., 2009 [139]	Surgery	Prospective cohort study	24	24	56.5	Mixed	Wexner score FIQL	/	/	/	/
Ellington et al., 2013 [140]	Gynaecology	Retrospective cohort study	407	407	56	Structural	FISI	/	/	/	/
Emile et al., 2016 [141]	Surgery	Retrospective cohort study	70	16	36	Structural	Wexner score	8-channel catheters (Sandhill Bioview Program, Milwaukee, WI)	(BK Medical, Herlev, Denmark) 16-MHz Probe	/	/
Farrell et al., 2010 [142]	Gynaecology	Prospective randomised clinical trial	149	149	29	/	Non-validated questionnaire	8-channel catheters (Laborie Medical Technologies, Inc., Montreal, Canada)	(B&K Medical, Sandhoften, Sweden) 10 MHz probe	/	/
Farrell et al., 2012 [143]	Gynaecology	Prospective randomised clinical trial	104	104	29	/	Non-validated questionnaire	/	/	/	/
Fashokun et al., 2012 [144]	Gynaecology	Prospective cohort study	505	505	53	/	Wexner score	/	/	/	/
Fellin et al., 2009 [145]	Radiotherapy	Prospective cohort study	1132	/	/	/	Non-validated questionnaire	/	/	/	/
Fitzpatrick et al., 2016 [146]	Gynaecology	Prospective cohort study	557	557		Structural	Modified Wexner score	water perfusion system with 8-channel (Synectics, Stockholm, Sweden)	Bruel & Kjaer, Naerum, Denmark) 10 mHz probe	/	/

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Table 1. Continued.

Study	Research area	Study design	no. of pts	F (*n*)	Mean age	FI aetiology	Tools	Anal manometry	Endoanal ultrasound	Defecography	Other
Fonseca et al., 2016 [147]	Gynaecology	Prospective cohort study	70	70	57.5	/	Wexner score FIQL	/	/	/	/
Formijne-Jonkers et al., 2012 [148]	Surgery	Retrospective cohort study	245	234	62	Structural	Wexner score	/	/	ns	dynamic MRI
Forsgren et al., 2010 [149]	Gynaecology	Case control study	117	117	72	Structural	Wexner score	/	/	/	/
Frees et al., 2016 [150]	Urology	Retrospective cohort study	90	/	62	/	Wexner score	/	/	/	/
Frudinger et al., 2010 [151]	Gynaecology	Prospective cohort study	10	10	/	Mixed	Wexner score FIQL	water-perfused six-channel catheter (Samsung, Sync Master 700 TFT)	B-K Medical Scanner, Type 2101 Falcon (B-K Medical, Herlev, Denmark)	/	PNTML (Dantec, Scovlunde, Denmark)
Frudinger et al., 2015 [152]	Gynaecology	Retrospective cohort study	10	10	/	Structural	Wexner score FIQL	water-perfused six-channel catheter (Samsung, Sync Master 700 TFT)	B-K Medical Scanner, Type 2101 Falcon (B-K Medical, Herlev, Denmark)	/	/
Frudinger et al., 2018 [153]	Gynaecology	Prospective cohort study	39	34	60.6	Structural	Wexner score	ManoScan™360 High-Resolution Manometry (Sierra Scientific Instruments, Los Angeles, CA, USA)	B-K Flexfocus Type 400 Medical Scanner fitted with a 2052 endoprobe (B-KMedical, Herlev, Denmark)	/	PNTML (Dantec, Scovlunde, Denmark)
Fu et al., 2012 [154]	Surgery	Retrospective cohort study	278	123	51	Structural	Wexner score	/	/	/	/
Gallas et al., 2010 [155]	Surgery	Prospective cohort study	200	194	60	Mixed	Wexner score FIQL	water-perfused system	ns	/	/
Gandomkar et al., 2015 [156]	Surgery	Prospective randomised clinical trial	99	66	38	/	Wexner score	/	/	/	/
George et al., 2013 [157]	Physiology	Prospective randomised clinical trial	30	28	57	/	Vaizey score FIQL	/	ns	/	/
George et al., 2014 [158]	Physiology	Retrospective cohort study	13	11	47	Neurogenic	Vaizey score FIQL	/	/	/	/
Gill et al., 2012 [159]	Physiology	Prospective cohort study	36	36	61.2	/	Non-validated questionnaire	/	/	/	/
Giordano et al., 2016 [160]	Surgery	Prospective cohort study	30	3	48	Structural	Wexner score	/	/	/	/
Gorissen et al., 2015 [161]	Surgery	Prospective cohort study	82	57	54	/	FISI FIQL GIQLI	/	/	/	/
Gosselink et al., 2013 [162]	Surgery	Prospective cohort study	72	67	59	Structural	FISI	water-perfused 9-lumen vector manometry catheter (MED 2280; Mediplus, High-Wycombe, UK)	(B&K Medical, Naerum, Denmark) 10-MHz probe	310-mL mixture of 100 mL of barium sulfate paste	/
Gosselink et al., 2015 [163]	Surgery	Prospective cohort study	91	86	61	Structural	FISI GIQLI	water-perfused 9-lumen vector manometry catheter (MED 2280; Mediplus, High-Wycombe, UK)	(B&K Medical, Naerum, Denmark) 10-MHz probe	310-mL mixture of 100 mL of barium sulfate paste	Endoscopy or CT colonography
Gourcerol et al., 2015 [164]	Physiology	Prospective cohort study	74	74	/	/	Wexner score	3D-HRM (Given Imaging, Yoqneam, Israel)	/	/	/
Govaert et al., 2009 [165]	Surgery	Prospective cohort study	22	16	60.4	Mixed	Wexner score FIQL	ns	ns	/	PNTML

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Table 1. Continued.

Study	Research area	Study design	no. of pts	F (*n*)	Mean age	FI aetiology	Tools	Anal manometry	Endoanal ultrasound	Defecography	Other
Graf et al., 2011 [166]	Surgery	Prospective rando-mised clinical trial	206	183	61	Mixed	Wexner score FIQL	/	/	/	/
Grande et al., 2010 [167]	Surgery	Retrospective cohort study	387	280	61	Mixed	Wexner score	flexible catheter with six channels (MUI Scientific, Mississauga, Ontario, Canada)	ns	ns	Endoscopy
Guinet et al., 2011 [168]	Neurology	Prospective cohort study	21	13	47.3	Neurogenic	/	(Latitude© equipment)	/	/	/
Gyhagen et al., 2014 [169]	Gynaecology	Retrospective cohort study	6148	6148	/	Structural	Wexner score	/	/	/	/
Habr-Gama et al., 2016 [170]	Surgery	Prospective cohort study	82	33	61.9	/	Wexner score FIQL	ALA CER (Multiplex II) manometer. 8-channel water-perfused catheter	/	/	/
Heilbrun et al., 2010 [171]	Gynaecology	Prospective cohort study	89	89	27.8	Structural	FISI	/	/	/	MRI
Heymen et al., 2009 [172]	Gastroenterology	Prospective rando-mised clinical trial	108	83	59.6	/	FISI FIQL	/	(10 MHz probe (Falcon© 2101EXL,B-K Medical, Herlev, Denmark)	/	/
Chan et al., 2017 [173]	Gynaecology	Prospective cohort study	442	442	30.6	/	PFDI PFIQ	/	ns	/	/
Horisberger et al., 2013 [174]	Surgery	Prospective cohort study	54	16	62	Structural	Wexner score	ns	ns	/	Endoscopy
Hornung et al 2012 [175]	Surgery	Prospective cohort study	100	100	57	/	Vaizey score	pull-through technique	(BK Medical, Herlev, Denmark) 10 MHz probe	/	/
Hornung et al 2014 [176]	Surgery	Prospective cohort study	52	52	57	/	Vaizey score	pull-through technique	(BK Medical, Herlev, Denmark) 3D 10-MHz probe	/	/
Horrocks et al., 2017 [177]	Surgery	Retrospective cohort study	205	185	/	/	Wexner score	/	/	/	/
Hotouras et al., 2012 [178]	Surgery	Prospective cohort study	88	88	58	Mixed	Wexner score	ns	ns	/	/
Hotouras et al., 2013 [179]	Surgery	Prospective cohort study	20	17	55	Mixed	Wexner score FIQL	water-perfused anal canal pull-through manometry	ns	/	/
How et al., 2012 [180]	Surgery	Prospective cohort study	62	21	63	Structural	EORTC QLQ Vaizey score	/	/	/	Endoscopy
Hull et al., 2013 [181]	Surgery	Prospective cohort study	120	110	60.5	Mixed	FISI FIQL	/	/	/	/
Huser et al., 2017 [182]	Gynaecology	Prospective cohort study	953	953	/	/	Wexner score	/	/	/	/
Hussain et al., 2012 [183]	Surgery	Prospective cohort study	38	24	66	Idiopathic	Vaizey score FIQL	8-channel catheter (Flexilog 3000, Oakfield Instruments Ltd, Evensham, Oxon, UK) pull through technique	(B&K, Denmark) 2D 10 mHz probe	/	PNTML
Hyman et al., 2009 [184]	Surgery	Prospective cohort study	245	83	46	Structural	FISI	/	/	/	/
Jamieson et al., 2017 [185]	Internal Medicine	Retrospective cohort study	47714	26751	82.5	/	InterRAI HC	/	/	/	/
Jelovsek et al., 2013 [186]	Gynaecology	Retrospective cohort study	921	921	/	Structural	FISI	/	/	/	/
Jelovsek et al., 2014 [187]	Gynaecology	Retrospective cohort study	133	133	57	Structural	FISI	/	/	/	/
	Surgery		981	612	73.6	Mixed		/	/	/	/

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Table 1. Continued.

Study	Research area	Study design	no. of pts	F (*n*)	Mean age	FI aetiology	Tools	Anal manometry	Endoanal ultrasound	Defecography	Other
Joh et al., 2010 [188]		Retrospective cohort study					Modified Rothenberger scale				
Johannessen et al., 2014 [189]	Physiotherapy	Prospective cohort study	1571	1571	28.2	Structural	Vaizey score	/	/	/	/
Johannessen et al., 2014 [190]	Physiotherapy	Retrospective cohort study	1571	1571	28.2	Structural	Vaizey score FIQL	/	/	/	/
Johannessen et al., 2017 [191]	Physiotherapy	Prospective randomised clinical trial	109	109	30.1	Structural	Vaizey score	Polygraf ID manometry machine with a catheter puller and POLYGRAM NET software (Alpine Biomed, USA)	2D and 3D EAUS B-K Medical type 2050 (B-K Medical Aps, Denmark) 2D EAUS (Hitachi EUB-6500, Providian Medical Equipment, USA)	/	EMG
Johannessen et al., 2018 [192]	Physiotherapy	Prospective cohort study	976	976	29	Structural	Vaizey score	/	/	/	/
Johannsson et al., 2013 [193]	Surgery	Retrospective cohort study	19	9	62	Structural	Miller's score	pull-through manometry	(Bruel & Kjaer Medical, Gentofte, Denmark) 10-MHz probe	/	/
Kahlke et al., 2011 [194]	Surgery	Prospective cohort study	214	97	55.3	Structural	Wexner score	/	/	/	/
Kahlke et al., 2015 [195]	Surgery	Prospective randomised clinical trial	31	31	55	Mixed	Wexner score	/	/	/	/
Kauff et al., 2016 [196]	Surgery	Prospective randomised clinical trial	188	/	/	/	Wexner score Vaizey score	/	/	/	/
Khan et al., 2015 [197]	Rehabilitation Medicine	Prospective randomised clinical trial	54	31	33.3	/	Wexner score	/	/	/	/
Khoury et al., 2013 [198]	Surgery	Retrospective cohort study	14	3	75	Structural	Wexner score	/	/	/	/
Kim et al., 2012 [199]	Surgery	Prospective cohort study	56	16	53	Structural	Wexner score	8-channel flexible catheter (Polygraf ID; Medtronics, Copenhagen, Denmark)	/	/	/
Kim et al., 2014 [200]	Surgery	Prospective cohort study	222	80	59	Structural	Wexner score	8-channel flexible catheter (Medtronics, Copenhagen, Denmark)	ns	/	/
Kirss et al., 2018 [201]	Surgery	Retrospective cohort study	236	215	64.5	Structural	Wexner score	ns	BK Medical®.	/	/
Kneist et al., 2013 [202]	Surgery	Case control study	15	2	65	Structural	Wexner score	/	/	/	/
Knowles et al., 2015 [203]	Surgery	Prospective randomised clinical trial	227	205	58	Mixed	Wexner score	/	/	/	/
Koch et al., 2009 [204]	Surgery	Prospective cohort study	35	31	59.7	/	Vaizey score	four-point solid state catheter (Konigsberg instrument Inc., Pasadena, California, USA)	(7.5 MHz, SDD 2000, Multiview, Aloka, Japan)	/	PNTML
Koyama et al., 2014 [205]	Surgery	Retrospective cohort study	178	54	65	Structural	Wexner score	/	/	/	/
Kuo et al., 2015 [206]	Surgery	Prospective cohort study	32	15	56.5	Structural	Wexner score	(Enraf nonius international Myomed 932, 2600 AV Delft, Netherlands)	/	/	EMG
Kye et al., 2016 [207]	Surgery	Prospective randomised clinical trial	47	22	63	Structural	Wexner score	/	/	/	/

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Table 1. Continued.

Study	Research area	Study design	no. of pts	F (*n*)	Mean age	FI aetiology	Tools	Anal manometry	Endoanal ultrasound	Defecography	Other
Laforest et al., 2012 [208]	Surgery	Case control study	46	20	57.5	Structural	Wexner score Kirwan's score FIQL	/	/	/	/
Lam et al., 2014 [209]	Gastroenterology	Prospective cohort study	31	31	61	/	Vaizey score FIQL	4-microtip transducer, water-perfused catheter (MuiScientific Type SR4B-5-0-0-0, Mississauga, Ontario, Canada)	3D diagnostic ultrasound system (Hawk type 2050, B-K Medical, Naerum, Denmark)	/	/
Lamb et al., 2011 [210]	Surgery	Retrospective cohort study	143	0	74	Structural	Wexner score CARIQ CARDI	/	/	/	/
Lambrescak et al., 2017 [211]	Surgery	Retrospective cohort study	144	130	61.3	/	Wexner score	/	/	/	/
La Torre et al., 2013 [212]	Surgery	Prospective rando-mised clinical trial	83	72	62.4	/	Wexner score FIQL	/	/	/	/
Martőnez-Vilalta et al., 2011 [213]	Surgery	Prospective cohort study	14	14	52	/	/	4 channels water-perfused catheter (PC Polygraph HR Synectics Medical®)	Brüel & Kjaer® (Nacrum, Denmark) 7 MHz probe	/	/
Lehur et al., 2010 [214]	Surgery	Prospective cohort study	14	14	62.8	Mixed	Wexner score FIQL	/	/	/	/
Lenisa et al., 2010 [215]	Surgery	Prospective cohort study	60	29	47	Structural	Wexner score	/	/	/	/
Leroi et al., 2011 [216]	Gastroenterology	Prospective cohort study	162	146	59	Mixed	Vaizey score	/	/	/	/
Leroi et al., 2012 [217]	Gastroenterology	Prospective rando-mised clinical trial	144	131	60	Mixed	Wexner score FIQL	standard technique with a perfused catheter	/	/	/
Leroi et al., 2018 [218]	Gastroenterology	Prospective cohort study	91	83	59	Mixed	Wexner score FIQL	3D-HRAM probe (Given Imaging, Manoscan 3D, Medtronic, MN, USA) EndoFLIP® system (Crospon, Inc., Galway, Ireland)	/	/	/
Liang et al., 2015 [219]	Surgery	Retrospective cohort study	57	24	47.8	Structural	Wexner score	/	/	/	/
Lin et al., 2016 [220]	Nursing	Prospective cohort study	53	11	64.1	/	Wexner score	/	/	/	/
Lin et al., 2018 [221]	Physiotherapy	Prospective cohort study	30	14	56	Structural	EORTC QLQ HRQoL	/	/	/	/
Lipschuetz et al., 2015 [222]	Gynaecology	Cross sectional study	198	198	28	Structural	PFBQ	/	/	/	/
Luglio et al., 2016 [223]	Surgery	Prospective cohort study	40	40	68	Structural	Wexner score	ns	/	ns	Endoscopy
Lukacz et al., 2015 [224]	Surgery	Prospective cohort study	91	82	68.6	Mixed	Wexner score	/	/	/	/
Madbouly et al., 2014 [225]	Surgery	Prospective rando-mised clinical trial	70	28	36.1	Structural	Wexner score CGQL	/	ns	/	/
Madbouly et al., 2015 [226]	Surgery	Prospective cohort study	71	28	/	Structural	Wexner score	/	/	/	Endoscopy
Maeda et al., 2009 [227]	Surgery	Prospective cohort study	109	75	57	/	Vaizey score	8-channel water-perfused system (Medical Measurement Systems MMS, Enschede, Holland)	(B&K Medical, Herlev, Denmark) 10 MHz probe	/	/
Magdy et al., 2012 [228]	Surgery	Prospective rando-mised clinical trial	150	49	32.3	/	Pescatori score GIQLI	Eight channel catheters	/	/	/
Manceau et al., 2013 [229]	Surgery	Retrospective cohort study	106	44	63	Structural	Wexner score EORTC QLQ	/	/	/	/
	Gerontology		155	155	58.7	/				/	/

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Table 1. Continued.

Study	Research area	Study design	no. of pts	F (*n*)	Mean age	FI aetiology	Tools	Anal manometry	Endoanal ultrasound	Defecography	Other
Markland et al., 2010 [230]		Retrospective cohort study					FISI Modified MHQ	water-perfused catheter system (Medtronic Inc, Minneapolis, MN)	(B&KMedical Systems Inc, Wilmington, MA) 10-MHz probe		
Markland et al., 2011 [231]	Gerontology	Prospective randomised clinical trial	291	291	53	/	Modified FISI	/	/	/	/
Markland et al., 2017 [232]	Gerontology	Prospective randomised clinical trial	67	35	58	/	ICIQ-B Vaizey score	/	/	/	/
Markland et al., 2017 [233]	Gerontology	Prospective cohort study	133	133	57	/	FISI Modified MHQ	/	/	/	/
Masoni et al., 2012 [234]	Surgery	Prospective randomised clinical trial	107	48	63	Structural	Wexner score	4 channel system (Polygraf ID, Sierra Scientific Instruments, Los Angeles, CA, USA)	/	/	/
Matsuda et al., 2015 [235]	Surgery	Prospective randomised clinical trial	100	33	68	Structural	Wexner score FIQL	/	/	/	/
Matsuoka et al., 2010 [236]	Surgery	Prospective cohort study	45	22	66.5	Structural	Wexner score	pull-through technique with a water perfusion catheter (Andorfer, Star Medical Inc., Tokyo, Japan)	/	/	/
McManus et al., 2015 [237]	Surgery	Prospective cohort study	85	85	62	Structural	Wexner score	ns	/	ns	PNTML
Mehmood et al., 2014 [238]	Surgery	Prospective randomised clinical trial	51	48	59	Structural	Wexner score FISI	/	ns	/	MRI Endoscopy
Melchior et al., 2014 [239]	Physiology	Retrospective cohort study	74	74	60.5	Mixed	Wexner score	ns	ns	/	MRI defecography Endoscopy PNTML
Mellgren et al., 2011 [240]	Surgery	Prospective cohort study	133	110	60.5	/	FISI FIQL	ns	ns	/	PNTML
Mellgren et al., 2014 [241]	Surgery	Prospective randomised clinical trial	136	122	61.8	Mixed	Wexner score FIQL	/	/	/	/
Mellgren et al., 2016 [242]	Surgery	Prospective cohort study	152	152	59.6	Mixed	Wexner score FIQL	/	/	/	/
Meurette et al., 2009 [243]	Surgery	Retrospective cohort study	27	/	62	/	Wexner score	/	ns	/	/
Michelsen et al., 2009 [244]	Surgery	Prospective cohort study	19	16	57.5	/	Wexner score	two-channel water-perfused system (Menuet, Dantec, Denmark) by a pull through technique	ns	/	/
Michot et al., 2010 [245]	Surgery	Retrospective cohort study	32	32	63	/	Wexner score	ns	ns	ns	MRI
Mion et al., 2017 [246]	Physiology	Prospective cohort study	126	113	52	/	Vaizey score Kess score GIQLI	(Medtronic, Shoreview, MN, USA)	(Brüel & Kjaer, Naerum, Denmark) or (Hitachi, Tokyo, Japan)	/	/
Mistrangelo et al., 2016 [247]	Surgery	Prospective cohort study	27	26	78	Structural	Wexner score	ns	/	ns	Endoscopy
Morris et al., 2013 [248]	Surgery	Prospective randomised clinical trial	35	/	/	/	Wexner score	closed balloon technique with a pressure monitor (Stryker).	(B&K Medical) 10 megahertz probe	/	PNTML
Moya et al., 2014 [249]	Surgery	Prospective cohort study	52	42	63.5	/	Wexner score FIQL	(SmartGI Anorectal Manometry System)	(Pro Focus Ultrasound Scanner model 2202 with a 360 rotating transducer model 2050)	/	/

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Table 1. Continued.

Study	Research area	Study design	no. of pts	F (*n*)	Mean age	FI aetiology	Tools	Anal manometry	Endoanal ultrasound	Defecography	Other
Moya et al., 2016 [250]	Surgery	Prospective cohort study	19	0	60	/	Wexner score	ns	ns	/	/
Murad-Regadas et al., 2013 [251]	Surgery	Prospective cohort study	31	31	39	/	Wexner score	8-channel manometer with ProctoMaster software (DynaMed, São Paolo, Brazil)	3D endoprobe (Pro-Focus 2052; 9–16 MHz; BK Medical, Herlev, Denmark)	/	/
Murad-Regadas et al., 2014 [252]	Surgery	Prospective cohort study	52	52	61	/	Wexner score	/	3D endoprobe (Pro-Focus 2052; 9–16 MHz; BK Medical, Herlev, Denmark)	/	/
Murad-Regadas et al., 2019 [253]	Surgery	Prospective cohort study	124	124	64	/	Wexner score	8-channel manometer with ProctoMaster software (Dynamed, São Paulo, Brazil)	3D endoprobe (Pro-Focus 2052; 9–16 MHz; BK Medical, Herlev, Denmark)	/	/
Ng et al., 2017 [254]	Gynaecology	Retrospective cohort study	506	506	30.6	/	PFDI PFIQ	/	/	/	/
Richter et al., 2019 [255]	Gynaecology	Prospective cohort study	73	73	61.3	/	Vaizey score FIQL	/	/	/	/
Nishigori et al., 2018 [256]	Surgery	Retrospective cohort study	30	7	67	Structural	Wexner score FISI FIQL	(Starlet ano ST4000/12P14-6; Star Medical, Tokyo, Japan)	/	/	/
Noelting et al., 2016 [257]	Gastroenterology	Prospective randomised clinical trial	44	44	58	/	FICA FISS FIQL	/	/	/	/
Nordenstam et al., 2010 [258]	Surgery	Retrospective cohort study	108	108	31	/	Pescatori score	8-channel water-perfused manometry with Synectics Polygram v 2.2 software (Medtronic Diagnostics, Minneapolis, MN)	(type 1850; B & K, Herlev, Denmark) 10-MHz probe	/	/
Norderval et al., 2013 [259]	Surgery	Retrospective cohort study	63	/	/	Mixed	Wexner score	/	/	/	PNTML
Oakley et al., 2016 [260]	Surgery	Prospective randomised clinical trial	54	54	29.8	Structural	FISI FIQL	4-channel catheter (T-doc-ARM4; T-DOC Company LLC, Wilmington, Del; Clinical Innovations LLC, Murray, Utah)	/	/	EMG
Oliveira et al., 2009 [261]	Physiology	Prospective cohort study	35	28	60.3	Mixed	Wexner score FIQL	8-channel water perfused system (Dynapack MPX 816; Dynamed, São Paulo, Brazil)	7.5-MHz probe	/	/
Oom et al., 2010 [262]	Surgery	Retrospective cohort study	117	117	58.5	Structural	FIQL	/	Kretz Voluson 730 expert system (GE Healthcare, Hoevelaken, The Netherlands) 4–8 MHz or 5–9 MHz probe	/	endoanal MRI
Oom et al., 2012 [263]	Surgery	Prospective cohort study	55	55	56	Structural	FIQL	/	(EUB 7000 HV, Hitachi Medical Systems) 10 MHz probe or GE Kretz Voluson 730 expert system (GE Healthcare, clinical systems, Hoevelaken, the	/	/

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Table 1. Continued.

Study	Research area	Study design	no. of pts	F (*n*)	Mean age	FI aetiology	Tools	Anal manometry	Endoanal ultrasound	Defecography	Other
									Netherlands), 5- 9 MHz probe		
Otto et al., 2013 [264]	Surgery	Prospective cohort study	40	21	43	Mixed	Wexner score	8 perfusion channels (Medtronic Software, Minneapolis, MN)	/	/	/
Richard et al., 2017 [265]	Rheumatology	Prospective cohort study	298	262	59.4	/	Wexner score FIQL	/	/	/	/
Paka et al., 2016 [266]	Surgery	Cross sectional study	486	486	57	/	Vaizey score	/	4D GE Kretz Voluson 730 Expert or Voluson S 6 systems (GE Medical Systems, Zipf, Austria) 8–4-MHz probe	/	/
Parc et al., 2009 [267]	Surgery	Prospective randomised clinical trial	364	/	/	Structural	FISI	/	/	/	/
Patton et al., 2013 [268]	Physiology	Prospective randomised clinical trial	11	10	/	/	Vaizey score	ns	B&K 2052 rotating anal probe (Bruel & Kjær, Nærum, Denmark)	/	PNTML
Patton et al., 2017 [269]	Surgery	Prospective cohort study	166	/	/	/	Vaizey score FIQL	ns	(2052 Bruel and Kjaer, Nærum, Denmark, rotating transducer)	/	PNTML
Peirce et al., 2013 [270]	Surgery	Prospective randomised clinical trial	120	120	/	/	Wexner score FIQL	ns	/	/	/
Perrenot et al., 2013 [271]	Surgery	Prospective cohort study	77	/	/	Structural	Wexner score	/	/	/	/
Pinedo et al., 2009 [272]	Surgery	Prospective randomised clinical trial	36	36	67	/	Wexner score	/	ns	/	/
Pinedo et al., 2012 [273]	Surgery	Prospective randomised clinical trial	50	/	61	/	Wexner score FIQL	/	ns	/	/
Prichard et al., 2017 [274]	Physiology	Retrospective cohort study	118	118	53	/	/	HRM catheter (Sierra Scientific Instruments; Los Angeles, CA)	/	/	MRI (MRInnervu, Medrad, Inc, Indianola, PA)
Pucciarelli et al., 2011 [275]	Surgery	Prospective cohort study	149	/	/	Structural	AMS score EORTC QLQ	/	/	/	/
Ramage et al., 2017 [276]	Surgery	Retrospective cohort study	161	161	32.9	Structural	Wexner score	T-DOC® Air-Charged™ ARM catheters	ns	/	/
Rao et al., 2014 [277]	Gastroenterology	Prospective cohort study	50	42	61	Structural	Vaizey score	6-sensor solid-state probe (Konigsberg Laboratories, Pasadena, CA)	/	/	PNTML
Ratto et al., 2010 [278]	Surgery	Retrospective cohort study	14	14	4706	Structural	Wexner score	water-perfused 4-channel catheter	(BK Medical, Herlev, Denmark)	/	/
Ratto et al., 2016 [279]	Surgery	Prospective cohort study	54	37	66	Mixed	Vaizey score Wexner score AMS score FIQL	/	ns	/	/
Reddymasu et al., 2009 [280]	Gastroenterology	Retrospective cohort study	27	20	56	Mixed	/	water-perfused catheter (Medtronic, Minneapolis, MN)	(PENTAX of America, Montvale, NJ) 5.0, 7.5 and 10 MHz probes.	/	/
Rezaie et al., 2015 [281]	Gastroenterology	Retrospective cohort study	39	31	64.7	Structural	Wexner score	3D HRAM (Given Imaging®)	BK Medical Flex Focus 400 system with a 2052 type 3D 16-6 MHz probe	/	/
	Surgery		100	98	60	Structural		/	/	/	/

(continued)

Table 1. Continued.

Study	Research area	Study design	no. of pts	F (*n*)	Mean age	FI aetiology	Tools	Anal manometry	Endoanal ultrasound	Defecography	Other
Ribaric et al., 2014 [282]		Prospective cohort study					Vaizey score KESS score				
Richter et al., 2015 [283]	Gynaecology	Prospective cohort study	61	61	61	/	FIQL Modified MHQ	/	/	/	/
Rimmer et al., 2015 [284]	Surgery	Prospective randomised clinical trial	43	38	60.5	Mixed	Wexner score	/	ns	/	/
Robert-Yap et al., 2010 [285]	Surgery	Retrospective cohort study	11	11	59	Structural	Wexner score ASCRS quality of life questionnaire	8-channel water perfusion catheter (ZineticsMedical, Salt Lake City, Utah) or multichannel manometry system (SEDIA SE-6; SEDIA AG, 1752 Givisiez, Switzerland)	ns	/	MRI
Rodrigues et al., 2017 [286]	Surgery	Retrospective cohort study	26	26	60	/	Wexner score	/	ns	/	PNTML
Rogers et al., 2014 [287]	Gynaecology	Prospective cohort study	782	782	25	Structural	Wexner score	/	/	/	/
Roman et al., 2013 [288]	Gynaecology	Retrospective cohort study	24	24	34.7	Structural	FIQL	/	/	/	/
Roman et al., 2016 [289]	Gynaecology	Retrospective cohort study	77	77	41	Structural	Wexner score GIQLI KESS score	/	/	/	/
Roos et al., 2012 [290]	Gynaecology	Prospective cohort study	159	159	31.5	Structural	Vaizey score	ns	B and K Viking 2400 system (Gentofte, Denmark) 13-MHz probe	/	/
Ros et al., 2017 [291]	Gynaecology	Retrospective cohort study	55	55	32.6	/	Wexner score	/	(type RIC5-9, Voluson-V730 Expert, GE) -4 MHz probe or (type 2052, Ultraview-800 BK-Medical) 13 MHz probe	/	/
Rosato et al., 2015 [292]	Surgery	Prospective cohort study	53	41	60	/	Wexner score FIQL	/	/	/	/
Rosenblatt et al., 2014 [293]	Gynaecology	Prospective cohort study	29	29	60.6	/	Wexner score FIQL	ns	/	ns	MRI PNTML
Roy et al., 2014 [294]	Physiology	Prospective cohort study	60	59	59	Mixed	Wexner score FIQL	ns	ns	/	EMG PNTML
Ruiz et al., 2010 [295]	Surgery	Prospective cohort study	24	23	72.8	Mixed	Wexner score FIQL	/	/	/	/
Rybakov et al., 2016 [296]	Surgery	Prospective randomised clinical trial	80	48	62	Structural	Wexner score FIQL	8-channel catheter (Lower GI Polygram, Synectics, Stockholm, Sweden). pull through technique	/	/	/
Rydningen et al., 2017 [297]	Surgery	Prospective randomised clinical trial	58	58	61	Structural	Vaizey score FIQL	/	/	/	PNE
Rygh et al., 2010 [298]	Gynaecology	Prospective randomised clinical trial	119	119	29	/	Wexner score	stationary pullthrough method using Polygraf ID 8 channel manometry system with Polygram NET software.	3D EAUS (Bruel & Kjær, Denmark; Hawk 2102 EXL, 2050 endoanal ultrasound probe)	/	/
Ryu et al., 2015 [299]	Surgery	Retrospective cohort study	53	18	60	/	Wexner score	single-channel pressure sensor, the GMMS	/	/	fecoflowmetry (FFM) (Takei

(continued)

Table 1. Continued.

Study	Research area	Study design	no. of pts	F (*n*)	Mean age	FI aetiology	Tools	Anal manometry	Endoanal ultrasound	Defecography	Other
								100/ACP 101 (StarMedical Co, Tokyo, Japan)			Medical & Optical Co, Tokyo, Japan)
Sansoni et al., 2013 [300]	Psychiatry	Prospective cohort study	61	51	/	/	Wexner score Vaizey score RFIS	/	/	/	/
Sauter et al., 2014 [301]	Gastroenterology	Prospective cohort study	26	15	/	/	Wexner score	HR-ARM device (Manoscan AR 360; Given Imaging, Yoquem, Israel)	(Siemens Sono Line Prima, 5–7.5 MHz; Siemens AG, Zurich, Switzerland)	/	Endoscopy
Schiano di Visconte et al., 2018 [302]	Surgery	Prospective cohort study	11	7	67.3	Structural	Wexner score FIQL	8 channels, stationary pull-through procedure (Polygraf™ ID multi-parametric recorder with POLYGRAM NET® analysis software, Medtronic, USA)	(type 2052, BK Medical, Analogic, Herlev, Denmark)	/	PNTML
Schwandner et al., 2010 [303]	Surgery	Prospective rando-mised clinical trial	158	/	79	Structural	Vaizey score Wexner score Parks's score FIQL	/	/	/	/
Schwandner et al., 2011 [304]	Surgery	Prospective rando-mised clinical trial	80	/	63	/	Wexner score	ns	/	/	/
Schwandner et al., 2013 [305]	Surgery	Prospective cohort study	9	3	61	Structural	Wexner score	(SPM-2100; M&B Biomedizintechnik, Traunstein, Germany)	/	/	/
Schwandner et al., 2014 [306]	Surgery	Prospective cohort study	38	0	51	Structural	Wexner score	(SPM-2100; M&B Biomedizintechnik, Traunstein, Germany)	ns	ns	MRI Endoscopy
Senapati et al., 2013 [307]	Surgery	Prospective rando-mised clinical trial	293	/	/	Structural	Vaizey score	/	/	/	/
Sileri et al., 2012 [308]	Surgery	Prospective cohort study	34	34	59	Structural	FISI Wexner score	/	/	ns	MRI Endoscopy or CT colography
Siproudhis et al., 2016 [309]	Gastroenterology	Prospective rando-mised clinical trial	466	390	62.1	/	Vaizey score Wexner score FIQL	/	/	/	/
Soerensen et al., 2009 [310]	Surgery	Prospective cohort study	33	24	53	/	Wexner score	Pull through technique	(type Falcon 2101 EXL; B-K Medical, Herlev, Denmark) 10 MHz probe	/	/
Soerensen et al., 2013 [311]	Surgery	Retrospective cohort study	363	363	50.4	Structural	Vaizey score Wexner score FIQL	/	/	/	/
Stafne et al., 2012 [312]	Gynaecology	Prospective rando-mised clinical trial	855	855	30.5	/	Vaizey score	/	/	/	/
Stedenfeldt et al., 2014 [313]	Gynaecology	Case control study	74	74	29.5	/	Vaizey score	/	/	/	/
Stephens et al., 2010 [314]	Surgery	Prospective cohort study	21	15	58.2	/	Wexner score FIQL FISI	ns	ns		Endoscopy PNTML MRI
Sturkenboom et al., 2018 [315]	Surgery	Retrospective cohort study	18	15	43	Mixed	Vaizey score Wexner score	/	/	/	/

(continued)

Table 1. Continued.

Study	Research area	Study design	no. of pts	F (*n*)	Mean age	FI aetiology	Tools	Anal manometry	Endoanal ultrasound	Defecography	Other
Sunesen et al., 2015 [316]	Surgery	Cross sectional study	84	76	58	/	Non-validated questionnaire	/	/	/	/
Sze et al., 2009 [317]	Gynaecology	Prospective cohort study	69	69	57	/	Pescatori score	/	/	/	/
Sze et al., 2013 [318]	Gynaecology	Cross sectional study	2319	52.5	50.1	/	Vaizey score	/	/	/	/
Dedemadi et al., 2018 [319]	Surgery	Prospective cohort study	22	13	64.1	Mixed	FIQL Wexner score	12-channel microballoon sensor (Star Medical Inc, Tokyo, Japan)	/	/	/
Tate et al., 2016 [320]	Urology	Cross sectional study	291	76	/	Neurogenic	FISI	/	/	/	/
Thin et al., 2014 [321]	Surgery	Prospective randomised clinical trial	40	39	59	Mixed	Wexner score FIQL	/	/	/	/
Thomas et al., 2013 [322]	Physiology	Prospective randomised clinical trial	30	26	52.5	/	Vaizey score FIQL	/	/	/	/
Thomas et al., 2015 [323]	Physiology	Prospective randomised clinical trial	11	10	/	/	Wexner score	/	/	/	/
Tjandra et al., 2009 [324]	Surgery	Prospective randomised clinical trial	40	36	59	/	Wexner score FIQL	pull-through technique	/	/	PNTML
Torrisi et al., 2011 [325]	Gynaecology	Prospective cohort study	960	960	29.8	/	Wexner score	/	/	/	/
Townsend et al., 2016 [326]	Physiology	Case control study	200	100	56.5	/	Wexner score	pull-through technique, (Medical Measurement Systems [MMS], Enschede, The Netherlands	(B-K Medical 2101, Berkshire, UK) 13 MHz probe	ns	/
Trenti et al., 2017 [327]	Surgery	Prospective cohort study	49	38	63.3	Mixed	Vaizey score	/	ns	/	/
Tsunoda et al., 2009 [328]	Surgery	Prospective randomised clinical trial	44	12	65.5	/	Wexner score	/	/	150 ml of a barium suspension	/
Tsunoda et al., 2013 [329]	Surgery	Prospective cohort study	20	4	42	/	Parks's score FISI	/	ns	/	MRI
Tuech et al., 2015 [330]	Surgery	Prospective cohort study	56	15	65	Structural	Wexner score	/	/	/	/
van Delft et al., 2014 [331]	Gynaecology	Prospective cohort study	269	269	30.7	/	Vaizey score	/	3D/4D TPUS using the GE Voluson 730 system with a 4–8 MHz probe	/	/
van der Hagen et al., 2011 [332]	Surgery	Prospective cohort study	50	9	38	/	Vaizey score	ns	ns	/	MRI
van der Hagen et al., 2012 [333]	Surgery	Prospective cohort study	70	70	54	Mixed	Wexner score Vaizey score FIQL	ns	ns	/	MRI
van der Wilt et al., 2017 [334]	Surgery	Prospective randomised clinical trial	59	51	64	/	Wexner score FIQL	ns	ns	ns	/
van Iersel et al., 2016 [335]	Surgery	Prospective cohort study	51	51	56.2	Structural	Pescatori score Wexner score Vaizey score	/	/	ns	MRI defecography Endoscopy
van Koperen et al., 2011 [336]	Surgery	Prospective randomised clinical trial	60	18	43.5	/	Vaizey score Wexner score COREFO	/	/	/	/
	Physiology	Retrospective cohort study	70	47	50	/	Non-validated questionnaire	high-Resolution manometry equipment, version 8.23	/	/	/

(continued)

Table 1. Continued.

Study	Research area	Study design	no. of pts	F (*n*)	Mean age	FI aetiology	Tools	Anal manometry	Endoanal ultrasound	Defecography	Other
van Meegdenburg et al., 2015 [337]								(medical measurement systems, enschede, netherlands)			
Visscher et al., 2017 [338]	Gastroenterology	Prospective randomised clinical trial	40	40	62	/	Vaizey score FIQL	4-microtip transducer, water-perfused catheter (Mui Scientific Type SR4B-5-0-0-0, Mississauga, ONT, Canada)	3-dimensional diagnostic ultrasound system (Hawk type 2050, B-K Medical, Naerum, Denmark)	/	/
Vitton et al., 2013 [339]	Gastroenterology	Retrospective cohort study	201	177	53.6	/	KESS score Wexner score	(MT 95000; Astromed, Inc., Elancourt, France)	/	/	/
Wahed et al., 2011 [340]	Surgery	Retrospective cohort study	65	/	62	Structural	Wexner score	/	ns	ns	Endoscopy Colonic transit
Wei et al., 2015 [341]	Surgery	Retrospective cohort study	81	63	50	Structural	Wexner score GIQLI	/	/	/	/
Whitcomb et al., 2012 [342]	Gynaecology	Prospective cohort study	98	98	43.3	/	FISI	/	/	/	/
Whitebird et al., 2010 [343]	Gastroenterology	Prospective randomised clinical trial	188	144	58	/	Non-validated questionnaire	/	/	/	/
Wijffels et al., 2012 [344]	Surgery	Retrospective cohort study	88	83	57.2	Mixed	FISI	/	/	ns	/
Wilson et al., 2018 [345]	Surgery	Prospective cohort study	64	39	51	/	COREFO	/	/	/	/
Savoye-Collet et al., 2010 [346]	Radiology	Retrospective cohort study	66	0	55.4	/	Park's score	/	/	ns	/
Muñoz-Yagüe et al., 2014 [347]	Gastroenterology	Retrospective cohort study	764	645	57.3	Mixed	Wexner score	Synetics Medical (Stockholm, Sweden)	/	/	/
Awad et al., 2015 [348]	Gastroenterology	Prospective cohort study	11	5	45	Mixed	Vaizey score	/	/	/	/
Wong et al., 2011 [349]	Surgery	Retrospective cohort study	10	10	64.5	Mixed	Wexner score FIQL	ns	ns	/	/
Wong et al., 2012 [350]	Surgery	Retrospective cohort study	28	28	63.5	Mixed	Wexner score FIQL	ns	/	/	/
Yeoh et al., 2009 [351]	Radiotherapy	Prospective randomised clinical trial	67	0	69	/	Non-validated questionnaire	ns	(Bruel and Kjaer, Naerum, Denmark) 7.5-MHz probe	/	/
Young et al., 2018 [352]	Surgery	Prospective randomised clinical trial	352	332	61	/	Vaizey score	/	/	/	/
Youssef et al., 2015 [353]	Surgery	Prospective randomised clinical trial	73	33	44.2	Structural	Wexner score Pescatori score	water perfusion system and 8 channel catheters, stationed pull-through technique	/	/	/
Youssef et al., 2017 [354]	Surgery	Prospective randomised clinical trial	62	62	41.4	Structural	Wexner score	ns	ns	ns	EMG PNTML
Zutshi et al., 2010 [355]	Surgery	Retrospective cohort study	53	53	48	/	FISI FIQL	ns	ns	/	/

n: number; pts: patients; F: female; FI: fecal incontinence; PNTML: pudendal nerve terminal motor latency; MRI: magnetic resonance imaging; ns: not specified; /: not reported; FISI: fecal incontinence severity index; FIQL: fecal incontinence quality of life; GIQLI: gastrointestinal quality of life index; EORTC QLQ: European Organisation for Research and Treatment of Cancer Quality-of-life Questionnaire; AMS: American medical system; COREFO: colorectal functional outcome; PFDI: pelvic floor distress inventory; PFIQ: pelvic floor impact questionnaire; EMG: electromyography; CT: computed tomography; FICA: fecal incontinence and constipation assessment; ICIQ-B: international consultation on incontinence questionnaire-bowel; MHQ: Manchester health questionnaire; FISS: fecal incontinence scoring system; InterRAI HC: international standardised geriatric home care assessment; ASCRS: American Society of Colon and Rectal Surgery; CARIQ: colon and ano-rectal impact questionnaire; CARDI: colon and ano-rectal distress inventory; HRQoL: health-related quality of life; PFBQ: pelvic floor symptom bother questionnaire; PNE: peripheral nerve evaluation; RFIS: revised fecal incontinence scale.

Table 2. Fecal incontinence assessment in IBD patients.

Study	Research area	Study design	No. of pts	F (*n*)	Mean age	Aetiology	IBD	Tools	Anal manometry	Endoanal ultrasound	Defecography	Other
Litta et al., 2019 [356]	Surgery	Prospective cohort study	37	16	40.6	/	30 CD 7 UC	Wexner score IBDQ	(EB Neuro, Florence, Italy)	3D-EAUS (model 2052; BK Medical, Herlev, Denmark)	/	/
Brochard et al., 2015 [357]	Gastroenterology	Prospective cohort study	19	10	39.5	/	10 UC	/	3-lumen water-perfused catheter (R3B & PIP4-4; Mui Scientific, Mississauga, ON, Canada)	/	/	/
Dibley et al., 2016 [358]	Nursing	Prospective cohort study	190	/	/	/	/	ICIQ-IBD	/	/	/	/
Dibley et al., 2013 [359]	Nursing	Retrospective cohort study	3264	2187	50.3	/	1599 UC 1534 CD 131 IC	Non-validated questionnaire	/	/	/	/
Khanna et al., 2013 [360]	Gastroenterology	Retrospective cohort study	45	21	40.5	/	41UC 2 CD 2 IC	/	(Trition manometry equipment; Laborie, Toronto, Canada)	/	/	/
Kozeluhova et al., 2017 [361]	Internal medicine	Prospective cohort study	57	57	29	Structural	17 UC 23 CD 17 HC	Vaizey score	/	/	/	/
Lam et al., 2014 [362]	Gastroenterology	Retrospective cohort study	46	34	51.5	/	12 UC 34 CD	IBDQ Vaizey score ICIQ-SF	4-microtip transducer, water-perfused catheter (Mui Scientific Type SR4B-5-0-0-0, Mississauga, Ontario, Canada) pull-through technique	3D diagnostic ultrasound system (Hawk type 2050, B-K Medical, Naerum, Denmark) 2–16 MHz probe	/	/
Norton et al., 2013 [8]	Nursing	Retrospective cohort study	3264	2178	50.26	/	1599 UC 1543 CD 122 IC	ICIQ-B IBDQ	/	/	/	/
Papathanasopoulos et al., 2010 [363]	Gastroenterology	Prospective cohort study	72	25	40	/	20 UC 38 CD 14 HC	Non-validated questionnaire	8 manometric channels (Medtronic, Innova, Athens, Greece)	(type 1850, BK Medical, Herlev, Denmark) 10-MHz probe	/	/
Papathanasopoulos et al., 2013 [364]	Gastroenterology	Prospective cohort study	58	18	42	/	20 UC 38 CD	FISS	stationary pull through (Medtronic, Minneapolis, MN).	(type 1850; BK Medical, Herlev, Denmark) 10-MHz probe	/	/
Perera et al., 2013 [365]	Gastroenterology	Retrospective cohort study	30	24	42.1	/	6 UC 24 CD	SIBDQ	(Medical Measurement Systems, Netherlands)	/	/	/
Quinn et al., 2017 [366]	Internal Medicine	Retrospective cohort study	115	66	44	Structural	94 UC	/	ns	/	ns	/
Raffals et al., 2014 [367]	Gastroenterology	Retrospective cohort study	42	27	42	Structural	/	/	ns	/	ns	/
Tremaine et al., 2013 [368]	Gastroenterology	Retrospective cohort study	177	125	48	/	62 UC 66 CD	/	ns	/	/	/
Vollebregt et al., 2017 [369]	Gastroenterology	Cross-sectional study	325	215	42	/	325 CD	Vaizey score Wexner score FIQL	/	/	/	/
Subasinghe et al., 2016 [370]	Surgery	Prospective cohort study	184	101	44.5	/	153 UC 31 CD	Vaizey score IBDQ	/	/	/	/
Andersson et al., 2011 [371]	Surgery	Retrospective cohort study	110	50	47	/	105 UC 1 IC	Wexner score HRQOL	/	/	/	/
Chung et al., 2010 [372]	Surgery	Retrospective cohort study	51	11	39	Structural	11 UC 40 CD	Vaizey score	/	/	/	/
	Surgery	Prospective cohort study	109	109	43	Structural	54 IBD	Wexner score	/	/	/	/

(continued)

Table 2. Continued.

Study	Research area	Study design	No. of pts	F (*n*)	Mean age	Aetiology	IBD	Tools	Anal manometry	Endoanal ultrasound	Defecography	Other
Cornish et al., 2012 [373]												
Kariv et al., 2009 [374]	Surgery	Retrospective cohort study	23	/	34,7	Structural	19 CD 4 IC	CGQL	/	/	/	/
Kuruvilla et al., 2012 [375]	Surgery	Prospective cohort study	59	20	53	Structural	59 UC	HRQOL SIBDQ CGQL FIQL	/	/	/	/
Vitton et al., 2009 [376]	Gastroenterology	Prospective cohort study	12	9	51	/	3 UC 7 CD 2 IC	Wexner score	/	/	/	/

n: number; pts: patients; F: female; UC: ulcerative colitis; CD: Crohn's disease; IC: indeterminate colitis; IBD: inflammatory bowel disease; ICIQ-IBD: incontinence questionnaire – inflammatory bowel disease; HC: healthy controls; IBDQ: inflammatory bowel disease quality of life questionnaire; ICIQ-SF: international consultation on incontinence questionnaire-short form; ICIQ-B: international consultation on incontinence questionnaire-bowel; FISS: fecal incontinence scoring system; SIBDQ: short inflammatory bowel disease questionnaire; HRQoL: health-related quality of life; FIQL: fecal incontinence quality of life; CGQL: Cleveland Clinic global QOL; /: not reported.

the Vaizey score (62 studies)[51,56,63,65,67,68,70,71,81,100,101,119,124,125,135–137,157,158,175,176,180,183,189–192,196,204,209,216,227,232,246,255,266,268,269,277,279,282,290,297,300,303,307,309,311–313,315,318,322,327,331–333,335,336,338,348,352] and fecal incontinence severity index (FISI; 33 studies).[42,60,72,84,85,93,109,115,118,140,161–163,171,172,181,184,186,187,230–232,238, 240,256,260,308,314,320,329,342,344,355] In 13 studies (4.2%)[53, 58,65,108,111,142,143,145,159,316,337,343,351] non-validated questionnaires were used. Anal manometry was used in 126 studies (41.2%)[50,53,55,57,61,65,72,73,77,78,80,82,83,85,86,91,92,95,96,98,103–107,109,111,115,122,123,125,127,134,141,142,146,151–153,155,162–165,167,168,170,174–176,178,179,183,191,193,199–201,204,206,213,217,218,223,227,228,230,234,236,237,239,240,244–251,253,256,258,260,261,264,268–270,274,276–278,280,281,285,290,293,294,296,298,299,301,302,304–306,310,314,319,324,326,332–334,337,338,347,349–351,353–355,362,376] for the evaluation of FI: eight-channel water-perfused manometries were the most common systems (in 22 studies).[61,83,122,125,141,142,146,170,183,199,200,227,251,253,258,261,264,285,296,298,302,353]

Endoanal ultrasonography was performed in 104 studies (34.0%).[53,65,72,73,76–78,80,83,86,90,92,104,105,109,110,113,115,122,125,127,133,141,142,146,151–153,155,157,162,163,165,167,172–176,178,179,183,191,193,200,201,204,213,225,227,230,238–240,243–246,248–253,258,261–263,266,268,269,272,273,276,278–281,284–286,290,291, 294,298,301,302,306,310,314,326,327,329,331–334,338,340,349,351,354, 355,362] In 26 studies (8.5%)[52,72,90,91,98,105,109,148,162, 163,167,223,237,245,247,293,306,308,326,328,334,335,340,344,346,354] the FI diagnostic approach included defecography. Other methods for FI evaluation implied PNTML investigation (23 studies),[104,105,115,151,153,165,183,204,237,239,240,248,258,268,269,277,286,293,294,302,314,324,354] MRI (20 studies),[52,96,104,111,148,171,238,239,245,262,274,285,293,306,308, 314,329,332,333,335] endoscopic procedures (18 studies),[77,78,98,163,167,174,180,223,226,238,239,247,301,306,308,314,335,340] EMG (five studies),[191,206,260,294,354] CT scan (two studies),[98,114] peripheral nerve evaluation (PNE; two studies),[75,297] CT colonography (two studies),[163,308] gastrointestinal transit time study (one study)[340] and fecoflowmetry (one study).[299] FI was diagnosed with one technique in 142 (46.4%) studies (questionnaires in 141 studies[51,54,56,58–60,62–64,66–71,74,79,81,84,87–89,93,94,97,99–102,108,112,116–121,124, 126,128–132,135–140,143–145,147,149,150,154,156,158–161,166,169,177, 181,182,184–190,192,194–198,202,203,205,207,208,210–212,214–216,219–222,224,229,231–233,235,241,242,254,255,257,265,267,271,275,282,283, 287–289,292,295,300,303,307,309,311–313,315–318,320–323,325,330,336, 341–343,345,348,352] or anal manometry in one study),[168] with two techniques in 64 trials (20.9%),[50,55,57,61,75,76,82,85,95,103,106,107,110,113,114,123,133,134,157,164,170–173,180,199,213,217,218,225,226,228,234,236,243,252,256,259,263,264,266,

270, 272–274,279, 280,284,291,296,297,304, 305,319,327, 328,331,337,344, 346,347,350,353,376 and with three or more combined methods in 100 studies (32.7%).[52,53,65,72,73,77,78,80,83,86, 90–92,96,98,104,105,109,111,115,122,125,127,141,142,146,148,151–153,155, 162,163,165,167,174–176,178,179,183,191,193,200,201,204,206,223,227,230, 237–240,244–251,253,258,260–262,268,269,276–278,281,285,286,290,293, 294,298,299,301,302,306,308,310,314,324,326,329,332–335,338,340,349,351, 354,355,362

Fecal incontinence assessment in IBD patients

In 17 trials (77.3%)[8,356,358,359,361–365,369–376] FI was evaluated using specific questionnaires. Ten different tools were adopted. The Wexner score, the Vaizey score and the inflammatory bowel disease quality of life (IBDQ) questionnaire were the most frequently used tools (in five (22.7%),[356,369,371,373,376] five (22.7%)[361,362,369,370,372] and four (18.2%)[8,356,362,370] studies, respectively). In two studies (9.1%)[359,363] non-validated questionnaires were applied. Anal manometry was used in 10 studies (45.4%) for FI assessment. Data concerning anal manometry were not specified in three studies (13.6%),[366–368] while in seven studies (31.8%)[356,357,360,362–365] singularly different systems were used. Anal ultrasound was performed in four studies (18.2%)[356,362–364] using Bruel and Kjaer medical probes in all cases. Defecography was used in two studies (9.1%).[366,367] However, no additional data were specified regarding diagnostic evaluation. In 15 studies (68.2%) the diagnosis of FI was obtained only with one technique (questionnaires in 12 studies[8,358,359,361,369–376] and anal manometry in three studies).[357,360,368] In three trials (13.6%)[365–367] two techniques were used, while in four papers (18.2%)[356,362–364] more than three methods were combined.

Discussion

We summarised all tools and investigations for FI diagnosis of the past 10 years in both IBD and non-IBD patients, including over 300 papers. Questionnaires represented the main technique for FI evaluation. They were used in almost all non-IBD studies and in over 75% of IBD trials. The most frequent tools in descending order of use were the Wexner score, FIQL, the Vaizey score and FISI for non-IBD patients and the Wexner score, the Vaizey score and the IBDQ for IBD patients. Patients' evaluation included anal manometry in about 40% of cases in both groups, while endoanal ultrasound was adopted more in non-IBD patients than in IBD patients (34.0% vs. 18.2%, respectively). Defecography was performed in a similar percentage of studies in both examined groups (8.5% vs. 9.1%), while investigations on anal physiopathology (such as PNTML and EMG) and morphological studies (such as MRI, CT scan and endoscopy) were used only in a small number of non-IBD patients. The difference in FI assessment between IBD and non-IBD patients could be due to several reasons. The management by many specialists, from the surgeon to the gastroenterologist to the gynaecologist, etc. could justify the different approaches. Moreover, in IBD patients the involuntary loss of feces could be attributed to the underlying disease rather than a concomitant FI related to other causes, determining not only an underestimation of the problem but also a less comprehensive approach. A recent systematic review and meta-analysis by Gu et al.[377] analysed the prevalence, pathophysiology and treatment of FI in IBD patients, reporting questionnaires and anal manometry as the main instruments for FI diagnosis. No additional tool was used to reach the diagnosis of FI. However, questionnaires are based on subjective responses of the patients and they could determine evaluation bias. Some psychometric properties,[101] such as sensitivity, validity, reliability and responsiveness are measured to overcome this limitation. The sensitivity and validity of four scores (Pescatori score, Wexner score, Vaizey score and American medical systems score) were assessed in a small prospective study[16] including 23 patients showing a high and significant correlation of all scores with the clinical impression of physicians. A prospective randomised clinical trial[101] compared the Vaizey score, Wexner score and FIQL scale in order to evaluate their responsiveness and interpretability. All instruments showed adequate external responsiveness (Pearson correlation (r)=0.60, r=0.44 and r=0.48, respectively) and interpretability (minimally important change (MIC)=20%, MIC=17.5% and MIC=33.8%, respectively) although none reached high psychometric levels. The main strength of our review is the large number of included studies, providing a summary of the evidence on FI diagnostic approaches in the past 10 years. Furthermore, to our knowledge it is the first paper that is specifically designed to investigate FI assessment, comparing the approach between IBD and non-IBD patients. However, there are some limitations. First of all, the marked heterogeneity of the studies, which included different scientific areas and took into account several patient populations and evaluation methods. Second, the study design of our work did not allow us to obtain sufficient data to compare the accuracy of the diagnostic tools and only direct comparative studies between the different methods will allow us to overcome this gap. Third, no distinction between ulcerative colitis and Crohn's disease in IBD trials was provided. Fourth, only studies published in the past 10 years were included in our systematic review representing a possible bias for result interpretation. There is no

globally accepted consensus on the FI diagnostic approach. The neuro-urological guidelines[378] state that the initial FI assessment should be based on a careful patient history using standard instruments such as Wexner and Vaizey scores. Digital rectal examination is considered an essential component for FI diagnosis, while the role of physiological and radiological tests is not established and their execution depends on the presence of alarm symptoms (e.g. weight or blood loss) or comorbidities.[378] The National Institute for Health and Care Excellence (NICE) guidelines,[379] instead, suggest clinical examination as a first step and a combination of anorectal physiology tests and endoanal ultrasonography (or MRI if ultrasonography is not available) in patients with FI who are candidates for surgical treatment. These data, as also indicated by our review, emphasize the lack of standardization in FI assessment. In some hospitals, colorectal units have been developed in order to manage complex FI cases. A retrospective study by Saunders et al.[380] analysed the impact of the colorectal unit on the rate of adverse events and functional outcomes. A multidisciplinary management resulted in reduced rates of post-treatment complications and in higher rates of functional outcomes compared to the pre-colorectal unit management.[380] However, the team consisted only of a surgeon, gastroenterologist, psychologist and a specialised nurse; some specialists who have a fundamental role in the management of patients with FI were not consulted. Currently, several tools have been developed to assess FI but there is no solid evidence on FI evaluation in the field of IBD. The Wexner and Vaizey scores are generic tools that can be applied to different research areas, including IBD. They are widely used in clinical practice as they are simple, quick and reliable.[381] The Wexner score is mainly focused on symptoms related to anal sphincter impairment and assesses the presence of solid, liquid, or gas incontinence.[381] The Vaizey score is based on the Wexner score and includes two additional parameters: defecation urgency and the use of constipating medication.[381] However, they do not evaluate patients' quality of life and were developed without any input from patients, ignoring patients' views. The International consultation on incontinence questionnaire-inflammatory bowel disease (ICIQ-IBD) is a new initially validated questionnaire, specifically structured for IBD patients.[358] It is based on both expert and patient inputs including a quality of life measure. Nevertheless, the ICIQ-IBD is hardly utilised, due to its complexity and lack of full validation.[381] To date, no score is perfectly fit for FI evaluation in IBD patients and data on the accuracy of FI diagnostic tools in the field of IBD are lacking, preventing definitive conclusions from being drawn. The Wexner score could be used, as the most appropriate for historical comparison, until a better tool is developed. The ongoing International Organization for the Study of Inflammatory Bowel Disease (IOIBD) consensus on endpoints for disease modification will determine which tools should be recommended for FI assessment in IBD patients. Therefore, based on the data of our work we propose to use the Wexner score as a first step for assessment of IBD patients with suspected FI. Other investigations should be performed only in the case of doubt and after multidisciplinary evaluation, including a team of experts consisting of a gastroenterologist, surgeon, gynaecologist, urologist, physiologist, neurologist, radiologist and psychologist. They should define the best diagnostic approach and guide therapeutic decisions, allowing better patient management and avoiding FI under/overestimation and misdiagnosis.

Conclusion

Fecal incontinence is a common and disabling condition in patients regardless of whether or not they have IBD. A validated and globally accepted algorithm to diagnose FI has not yet been defined. A detailed history, including the characteristics of the feces and the type and frequency of incontinence, is necessary promptly to identify red flag symptoms. In the past 10 years questionnaires have been the most frequently used tools for FI evaluation. Based upon validation and global researcher preference, we propose to start FI assessment of IBD patients with the Wexner score. Any future instrument development might best be achieved by interdisciplinary international collaboration. Anal manometry and/or endoanal ultrasonography should be considered when questionnaires are suggestive of fecal incontinence.

Author contribution

FD wrote the manuscript with support from CG. SD critically reviewed the content of the paper and supervised the project. CV and SW performed critical appraisal of the data and critical revision of the paper. LPB conceived the study, contributed to the critical interpretation of the results and supervised the project. All authors discussed the results and contributed to the final paper.

Declaration of conflicting interests

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