REVIEW

Current aspects and future prospects of total anorectal reconstruction—a critical and comprehensive review of the literature

Roman A. Inglin · Daniel Eberli · Lukas E. Brügger · Tullio Sulser · Norman S. Williams · Daniel Candinas

Abstract

Purpose Many rectal cancer patients undergo abdominoperineal excision worldwide every year. Various procedures to restore perineal (pseudo-) continence, referred to as total anorectal reconstruction, have been proposed. The best technique, however, has not yet been defined. In this study, the different reconstruction techniques with regard to morbidity, functional outcome and quality of life were analysed. Technical and timing issues (i.e. whether the definitive procedure should be performed synchronously or be delayed), oncological safety, economical aspects as well as possible future improvements are further discussed.

Methods A MEDLINE and EMBASE search was conducted to identify the pertinent multilingual literature between 1989 and 2013. All publications meeting the defined inclusion/exclusion criteria were eligible for analysis.

Results Dynamic graciloplasty, artificial bowel sphincter, circular smooth muscle cuff or gluteoplasty result in median resting and squeezing neo-anal pressures that equate to the measurements found in incontinent patients. However, quality of life was generally stated to be good by patients who had undergone the procedures, despite imperfect continence, faecal evacuation problems and a considerable associated morbidity. Many patients developed an alternative perception for the urge to defecate that decisively improved functional outcome. Theoretical calculations suggested cost-effectiveness of total anorectal reconstruction compared well to life with a permanent colostomy.

Conclusions Many patients would be highly motivated to have their abdominal replaced by a functional perineal colostomy. Given the considerable morbidity and questionable functional outcome of current reconstruction technique improvements are required. Tissue engineering might be an option to design an anatomically and physiologically matured, and customised continence organ.

R. A. Inglin (✉) · L. E. Brügger · D. Candinas
Department of Visceral Surgery and Medicine, Bern University Hospital, University of Bern, Freiburgstrasse 10, CH-3010 Bern, Switzerland
e-mail: roman.inglin@insel.ch

D. Eberli · T. Sulser
Laboratory for Tissue Engineering and Stem Cell Therapy, Department of Urology, University Hospital Zurich, Sternwartstrasse 14, CH-8091 Zurich, Switzerland

N. S. Williams
National Centre for Bowel Research and Surgical Innovation, Barts and The London School of Medicine and Dentistry, The Royal London Hospital, 2 Newark Street, London E1 2 AT, UK

Introduction

The global annual incidence of colorectal cancer accounts for more than 1 million patients, and about in one third of those with the malignancy the disease originates in the rectum [1–3]. Most of these patients undergo surgery since complete excision of this cancer represents the mainstay of treatment. Over the last two decades, various therapeutic advances have led to a continuous decrease in the number of oncologically necessary abdominoperineal excisions (APER). While an APER rate of about 30 % (range 10–52 %) [4–11] is reported in current literature, an estimated percentage of 20 % may be more congruent with the up-to-date situation. This still means an approximate annual rate of 50,000 such operations along with a permanent abdominal colostomy worldwide, entailing substantial morbidity [12, 13], negative impact on patient's quality of life (QoL) [14] and health care costs. Furthermore, some patients fail to adapt to their body image and suffer psychosocially [15]. Religious, cultural and social

backgrounds seem to influence substantially the patients' ability to cope with an abdominal colostomy [16]. Almost 30 % of stomas develop complications, and approximately 10 % require a second operation due to stenosis, prolapse, parastomal hernia or leakage [17]. For those, particularly young and fully active patients, who request an alternative, several methods have been suggested in an attempt to restore gastrointestinal continuity and continence, and these are referred to as total anorectal reconstruction (TAR). However, the most appropriate technique has not yet been defined, and the considerable shortcomings of each procedure call for improvements.

In this review, we analysed the current techniques of TAR after APER with respect to morbidity, functional outcome and QoL. Questions such as the impact of technical details and timing of the definitive reconstructive procedures on outcome, oncological safety, economical aspects as well as possible future improvements are discussed.

Materials and methods

Study selection

Literature searches in English-, German-, French-, Italian-, and Spanish-language publications (abstract always in English) were performed using the National Library of Medicine (PubMed) as well as the EMBASE database. The queries included the keywords "perineal", "anorectal", "reconstruction", "colostomy", "abdominal", "appendicostomy", "coecostomy", "Malone", "dynamic graciloplasty", "musculoplasty", "gluteoplasty", "artificial bowel sphincter", "pseudocontinent", "Schmidt", "electrically stimulated gracilis", "neo-sphincter", "colonic conduit", "quality of life", "morbidity", "continence" and "functional outcome". A free-text strategy was applied limiting the year of publication from 1989 up to 2013. Links to related articles and cross-reading of citations in related articles were surveyed. Keywords were combined to narrow or widen the search. Based on the title and abstract of the publication, full articles were either downloaded or requested through this institution's library. The retrieved publications were assessed for their eligibility using the following criteria.

Inclusion criteria

Controlled trials, case-control studies, prospective and retrospective cohorts as well as case series that evaluated the outcome of patients undergoing TAR after APER for malignancy with respect to morbidity, and/or functional results and/or quality of life.

Exclusion criteria

Letters, abstracts, comments and reviews with insufficient details were excluded as well as studies where a combined technique (e.g. DGP and CSMC) was used for reconstruction, and/or having been published earlier than 1989, and/or comprising patients undergoing APER due to other reasons than cancer and/or where the indication for operation was not obvious.

Where apparently sequential publications of a continuously increasing patient's data record were published all, but the most recent of those publications were excluded from analysis.

Data extraction

Since the pertinent literature provided in the main only case series and cohort studies rather than controlled trials, the aim of this study was a critical analysis and discussion of the available data addressing the main points of controversy of TAR after APER. Pooling of original raw data and separate analysis were not done.

Results

Simple perineal colostomy and adjuncts

Simple perineal colostomy alone yields poor levels of continence. To overcome this, Malone et al. [18] introduced the concept of using an appendicostomy for antegrade enema instillation in order to improve disturbed continence in children after the surgically corrected congenital anorectal malformations. This technique has also been applied to improve continence after perineal colostomy after APER.

We identified three publications [19–21] encompassing a total of 46 patients (23 female, 23 male) with a median age of 58 years (range 26–77) who had undergone this combination of procedures (Table 1). Morbidity, including orifice abscesses, infection, necrosis or stenosis of the caecal or appendiceal conduit, small bowel obstruction, prolapse of the perineal colostomy, eventration and urologic complications, are reported in two of these publications with an incidence of 33 and 56 %.

Penninckx et al. [21] obtained a faecal pseudocontinence in 7/12 (58 %) patients, and Portier et al. [20] achieved an average Cleveland Clinic score of 6.41/20, which means a considerable level of continence after 6 months of follow-up. Manometry data were not available.

Patients scored their general condition and QoL within the topmost fourth of the scale, using the European Organisation for Research and Treatment of Cancer (EORTC) Quality of

Table 1 Perineal colostomy with appendicostomy/cecostomy (Malone)

Reference	Year	Study design	n	Gender m/f	Median age (years)	Morbidity (%)	Follow-up (months)	Remarks
Farroni [1]	2007	CC	13 (vs. 14)[a]	6/7	61	n.s.	20 (15–45.5)	Overall QoL and self-perceived health was good; sexual problems were most dominant
Portier [2]	2005	CS	18	10/8	58	56	6	Regular antegrade enema every 24 or 48 h; no preoperative QoL scores
Penninckx [3]	2005	CS	15	7/8	55	33	24 (6–55)	The general health status and QoL were estimated at 75 % from normal value

CC case control, *CS* case series, *n.s.* not specified

[a] Versus abdominal colostomy

Life questionnaires (QLQ-C30/-CR38) or Fecal Incontinence Quality of Life (FIQL) scales. As part of the regime, patients did need regular antegrade enemas to empty the colon and, thus, achieved pseudocontinence. However, Farroni et al. [19] who compared the outcome of patients with an abdominal colostomy to those who received a Malone's procedure after APER, found no significant difference in perceived health status, symptoms and QoL. Sexual problems were reported to be the most dominant in male patients [19].

In order to further improve continence of the restored perineal colostomy after APER, different neo-sphincter procedures have been proposed, referred to as total anorectal reconstruction (TAR).

Dynamic graciloplasty

Dynamic graciloplasty (DGP) was first reported in 1988 by Baeten et al. [22] and used primarily to treat acquired faecal incontinence. Twenty-three studies evaluating DGP for TAR after APER could be identified. Thirteen studies, consisting of a total of 322 patients (136 female, 186 male), were eligible for further analysis [23–35] (Table 2). The median age of the patients was 59 years (range 32–88). Postoperative morbidity (within 30 days of the operation) including colonic necrosis, occlusion or fistula, neo-sphincter stenosis, perineal or groyne abscess, ileostomy prolapse, separation of the gracilis muscle, electrostimulator sepsis range from 14 to 74 % [31, 35] and a late complication rate (>30 days after intervention) of up to 90 % was reported [23].

Neo-anal manometry was performed in two thirds of the analysed studies encompassing 163 patients, yielding a median resting (or basal) and squeeze (or maximal) sphincter pressure of 25 and 102 mmHg, respectively. Despite the relatively low manometric sphincter pressures, subjective perception of continence was rated consistently high. Utilising either the Wexner's or Williams' incontinence scores, in all but one of the eligible studies, 53 to 90 % of the patients quoted continence to at least solid and liquid stool [32, 34]. In one study, however, results were sobering, namely referring to occasional episodes of incontinence to solid faeces in all the patients where a primary diverting stoma was eventually closed, and they needed to wear pads to cope with their persistent faecal soiling [33]. In general, many patients who underwent TAR using DGP needed regular retrograde irrigation of the neo-rectum and/or the use of laxatives or constipative agents, respectively, in order to achieve the reported levels of continence.

Only three of the eligible studies dealt with QoL. Rouanet et al. [29] reported a positive overall QoL of 78 % in their series. Utilising the QLQ-C30 and QLQ-CR38 questionnaires, Abbes Orabi et al. [23] reported overall scores of 66.7 at 31 months, 75 at 40 months and 70.9 at 78 months (where a score of 100 corresponds to perfect function). They concluded that QoL remained stable over time. Cavina et al. [28] found that 96 % of the patients achieved a Karnofsky score between 90 and 100, hence were fully active at the time of evaluation. Indeed, the authors concluded that the global performance of the treated patients was not significantly different from that of a random sample of the general population.

Artificial bowel sphincter

The artificial bowel sphincter (ABS), first described in 1987 [36] for the treatment of faecal incontinence, was also utilised for TAR after APER. Three case series, encompassing a total of 12 patients with a median age of 59 years (range 46–76; 1 male, 11 female) were appropriate for analysis (Table 3). Morbidity ranged from 50–100 %, with evacuation difficulty being a particular problem but also wound infection and erosion of the ABS through the colon wall [37–39].

Two studies comprising nine patients reported results on neo-anal manometry. The median intraluminal pressure gradient between the deflated and inflated cuff of the ABS was 35.3 mmHg [37, 39], a value substantially below the difference between basal (resting) and maximum (squeeze) pressure after TAR using DGP. Functional outcome, however, was generally found to be good. Applied to an adjusted scale merging different score systems, their description of the mean incontinence level corresponded to 0.2–0.3 where 0 would be complete continence and 1 equals total incontinence (to solid

Table 2 Dynamic graciloplasty for total anorectal reconstruction

Reference	Year	Study design	n	Gender m/f	Median age (years)	Morbidity (%)	Neo-sphincter pressure (mmHg)	Follow-up (months)	Remarks
Abbes Orabi [4]	2009	CS	10[a]	3/7	40	90	n.s.	78 (range 51–94)	"Good" "functional outcome; QoL stable or improved over time
Ho [5]	2005	CS	17	12/5	59	65	n.s.	n.s.	82 % continent without need for gracilis stimulation; 55 % defecatory problems
Violi [6]	2004	CS	23	11/12	66	22 % (major), 65 % (minor)	n.s.	up to 96	100 % "very good" and "good" results 3–5 years postoperatively; only 70 % takedown of the diverting abdominal stoma
Rosen [7]	2002	CS	35	26/9	58	n.s.[c]	BP 40, MP 91	45 (range 5–97)	"Satisfactory" functional results are not defined
Rullier [8]	2000	CS	15	10/5	54	73	BP 24, MP 147	28 (range 3–48)	
Cavina [9]	2000	CC	27 (vs. 27)[b]	14/13	73	n.s.	n.s.	131 (range 93–172)	96 % of the patients perform enema to facilitate emptying and prevent soiling
Rouanet [10]	1999	CS	9	4/5	51	33	BP 24, MP 95	32 (range 14–50)	33 % new defecation sensation with improved functional results
Madoff [11]	1999	MCT	35	15/20	60	n.s.	n.s.	24	67 % required enemas or laxatives to facilitate evacuation
Cavina [12]	1998	CS	31	17/14	61	74	BP 56, MP 147	38 (range 4–68)	
Geerdes [13]	1997	CS	20	8/12	52	33	BP 40, MP 138	24 (range 1–60)	Addition of pouch (4/20) did not improve results; 38 % of the continent patients required regular enemas for their continence
Mander [14]	1996	CS	12	9/3	59	n.s.	BP 22, MP 90	54 (range 3–79)	All patients with closed diverting stoma reported difficulty in evacuation and achieved satisfactory continence by the use of constipating agents and by neo-rectal irrigation.
Cavina [15]	1996	CS	81	54/27	62	37 bzw. 20	BP 22 MP: 109	79	
Mercati [16]	1991	CS	7	3/4	49	14	BP 12, MP 70	23 (range 4–58)	

BP basal (resting) pressure, *MP* maximal (squeezing, electrostimulated or voluntary contraction) pressure, *CS* case series, *CC* case control, *MCT* multicentre trial, *n.s.* not specified

[a] DGP+Malone

[b] Versus healthy control

[c] Nineteen complications in 35 patients

Table 3 Artificial bowel sphincter implanted as a neo-sphincter

Reference	Year	Study design	n	Gender m/f	Median age (years)	Morbidity (%)	Cuff pressure (mmHg)	Follow-up (months)	Remarks
Marchal [17]	2005	CS	3	0/3	58	n.s.	GP 39.7	30 (mean)	All patients felt improvements in both continence score and quality of life assessment
Lirici [18]	2004	CS	3 (vs. 3)[a]	1/2	63	100	n.s.	ABS 5.5 (mean) DGP 14 (mean)	No stoma closure performed
Romano [19]	2003	CS	6	0/6	59	50	GP 28.5 Ci 62 Cd 33.5		

CS case series, *GP* gradient pressure: difference between pressure of the in- and deflated cuff, *Ci* cuff inflated, *Cd* cuff deflated

[a] Versus dynamic gracialoplasty

and liquid stools, and flatus). Though, all patients needed regular enemas via the neo-rectum to achieve both satisfactory continence and proper evacuation.

Utilising FIQL and QLQ-C30 questionnaires, Romano et al. found a significant improvement of patient's QoL after ABS implantation [39]. Yet, detailed data cannot be summarised due to inconsistent or missing results.

Circular smooth muscle cuff

Three decades ago, Schmidt et al. [40] described another technique to achieve a (pseudo-) continent colostomy by fashioning a sleeve of colonic smooth muscle around the perineal colostomy. For almost 25 years, this method, also referred to as circular smooth muscle cuff (CSMC), has been adopted for TAR, as either synchronous or delayed reconstruction after APER.

A total of 6 case series including 209 patients with an estimated median age of 55 years were eligible for analysis [41–46] (Table 4). The perioperative morbidity ranged from 22 to 76 %, including colon necrosis with or without the cuff, perineal wound problems, evacuation difficulties, perianal dermal stenosis, mucosal polyps and prolapse, colovaginal fistula and neo-sphincter insufficiency, but also non-specific complications such as pneumonia, urinary infection or pulmonary embolism.

One study (n=27) which included manometry studies showed median resting and compression pressures of the neo-rectum of 29.4 and 70.6 mmHg, respectively [42]. A total of 121 patients included in four studies were analysed with respect to continence using different classifications such as the Kirwan-Fazio, Vaizey, and modified Kelly-Holschneider score. Continence was generally stated as "good" or "satisfactory" in 59–71 % of the patients [44–46], whereas one study reported over 80 % of the patients being continent after a median follow-up of 105 months (range 18–185 months)

[42]. Some patients needed retrograde neo-rectal irrigation to facilitate continence.

Two case series (n=39 patients) dealt with QoL, using the EORTC QLQ C-30 and −38 questionnaires. They reported a median global health status/QoL of 67–75, which is comparable to that reported for TAR using DGP.

Gluteoplasty

More than 80 years ago, gluteoplasty was used in early attempts to restore continence after APER [47]. This technique fell into oblivion until Sato et al. in 1997 published a case report [48], and in 2005 published further data on 19 patients (17 men, 2 women; median age, 62 years; range, 46–73) who received APER and gluteoplasty with a pudendal nerve anastomosis at the same time [49]. They reported 18 complications in 17 patients, including mainly skin necrosis around the incision for muscle harvesting, but also perineal wound infection, colon necrosis, dehiscence of the anchoring of the neo-sphincter, small bowel obstruction and narrowing of the perineal stoma. Manometry studies showed a mean resting and squeezing pressure of 29.2 and 135.1 mmHg, respectively. A mean Jorge-Wexner score of 12.2 (SD±3.29) was reported. Patients answering to the World Health Organization QoL-BREF questionnaire quoted an overall score of 3.53 (SD± 0.26) on a scale ranging from 1 (worst) to 5 (best).

More recently, Puerta Diaz et al. [50] presented their results on 7 patients (5 male, 2 female) with a median age of 40 years (range 30–66). All received a metachronous gluteoplasty without nerve anastomosis two to ten years after APER. The morbidity rate in this series was 29 %, namely one perineal sepsis, and one patient suffering from a fibrotic stricture in the colocutaneous anastomosis that required several digital dilatations. Neo-anal manometry yielded resting pressures from 10–18 mmHg, and voluntary contraction pressures from 68–187 mmHg. The Cleveland Clinic Florida faecal incontinence (Jorge-Wexner) score was a median value of 5 (scale 0–20).

Table 4 Musculoplasty to restore functional perineal colostomy

Reference	Year	Study design	n	Gender m/f	Age (years)	Morbidity (%)	Neo-sphincter pressure (mmHg)	Follow-up (months)	Remarks
CSMC									
Dumont [20]	2012	CS	31	11/20	53	48	n.s.	60	
Hirche [21]	2010	CS	27	17/10	55	76	BP 29 MP 71	105 (18–185)	Similar functional outcome between primary and secondary reconstruction
Pocard [22]	2007	CC	12 (vs. 38)[a]	n.s.	56	n.s.	n.s.	120 (24–180)	Vaizey score 11 (8–13); fractioned stools 50 %, soiled pads 92 %
Lasser [23]	2001	CS	40	27/13	50	68	n.s.	45 (18–87)	33 patients highly satisfied, 3 patients moderately satisfied, 2 patients unsatisfied (who finally underwent abdominal colostomy)
Gamagami [24]	1999	CS	63	31/32	60	65	n.s.	12	
Federov [25]	1989	CS	36	12/24	range 25-59	22	n.s.	14 (6–42)	85 % urge to defecate, can distinguish between faeces and gas; good functional results (not defined herein) achieved in 77 %
Gluteoplasty									
Puerta Diaz [26]	2013	CS	7	5/2	40	29	BP 10–18, MP 68–187	47 (10–123)	
Sato [27]	2005[b]	CS	19	17/2	62	n.s.[c]	BP 29, MP 135P: 135	38 (10–99)	Binding medicine used in 4 patients (40 %); laxatives used in 3 patients (30 %)

BP basal (resting) pressure, *MP* maximal (squeezing, voluntary contraction, compression) pressure, *CS* case series, *CC* cohort control, *n.s.* not specified

[a] Versus coloanal anastomosis

[b] With pudendal nerve anastomosis

[c] Eighteen complications in 17 patients

More than half the patients were able to defecate spontaneously without difficulty. QoL was not specifically assessed in this study (Table 4).

Discussion

Simple perineal colostomy alone as one of the proposed reconstruction techniques provides poor levels of continence. However, it may perfectly fill the "dead space" in the pelvis, and so promote perineal wound healing [41], particularly being effective in this regard after preceding radiotherapy [51]. The possibility to perform a digital examination of the pelvis to facilitate diagnosis of early local recurrence may also be another advantage of a perineal colostomy. While the reservoir function intuitively is compromised due to the lack of distensibility of the neo-rectum, the addition of a colonic pouch to a perineal reconstruction using DGP did not show

improvement in functional outcome compared to DGP alone [29, 32].

TAR is associated with considerable morbidity. Whether appendico-/cecostomy, or more complex procedures, such as DGP, ABS, CSMC or gluteoplasty are performed, almost half of the patients suffered one or several complications. While perineal infection was the most frequent complication reported after TAR, colonic ischemia was the most serious. However, no intervention-related mortality was reported.

While neo-anal pressures after DGP, ABS, CSMC and gluteoplasty were below those recorded in healthy volunteers [52, 53], they equate to measurements found in incontinent patients [54]. However, the discrepancy between objective functional results and QoL in patients suffering from faecal incontinence has been described previously [55]. Indeed, despite considerable morbidity and imperfect continence, QoL is generally stated to be good after TAR, similar to patients undergoing sphincter-preserving oncological resection and coloanal anastomosis [43], and definitely better compared to

the situation with abdominal colostomy [39, 49]. Taking these results into account, the effort undertaken to convert an abdominal to a perineal colostomy may well be justified for the highly motivated patient who understands the risks despite the inherent high-morbidity rate [35, 33, 48].

All would agree that oncological safety must be paramount when TAR is performed. Several studies confirmed local and distant recurrence rates after TAR were similar to patients after classical APER [29, 32, 33, 56]. While success rate does not seem to differ whether TAR is performed synchronously with APER or after a chronological delay [30, 42], results on complication rate are conflicted [30, 31]. However, TAR and APER performed synchronously seems to be no different from a morbidity point of view. Not surprisingly, prior experience of the surgeon in performing a TAR procedure has an impact on outcome. Substantially lower overall success rate and higher probability of experiencing a major wound complication in the first 12 months was reported when TAR was performed by less expert hands [30].

DGP and CSMC are by far the most commonly used procedures to create a neo-sphincter as part of TAR. However, the technical details may vary between studies. The choice of the muscle used and the configuration of transposition have been an issue of considerable debate, but no individual centre has obtained broad experience with various techniques. Madoff et al. showed that there was no correlation between success (defined as at least a 70 % reduction of incontinent incidents to solid stool compared with baseline status) and technical details such as wrap configuration, completeness of muscle coverage, site of the anchor point when the gracilis was used. Consequently, the authors suggested avoiding undue attempts to reach 100 % muscle coverage by applying excessive tension to the wrap in order not to take the disproportionate risk of subsequent neo-rectal perforation [30].

Success defined as the degree of continence is not only a matter of neo-sphincter function, but also of evacuative function, anorectal sensation and reservoir capacity [57]. For obvious reasons, particularly the latter two are considerably impaired in TAR after APER. However, with time, some patients develop an alternative form of perception such as periumbilical sensation, hypogastric "murmur" or tension on the transplanted muscle [32, 58]. Many publications emphasised the importance of recovering some kind of sensitivity in order to achieve improved functional results [29, 34, 48, 49, 59–61]. Seccia et al. reported that 10 of 25 patients could perceive solid stool in the neo-rectum and 12 could discriminate between gas, liquid and solid [56]. In the authors' opinion, the poor results in four patients were due to the failure to perceive the urge to defecate. Not only after DGP, but also after reconstruction using CSMC, a high number of patients were found to sense an urge to defecate, and to be able to distinguish between faeces and gas after a certain time

postoperatively [46]. A very common problem encountered after TAR, almost independently from the technique applied, were difficulties to evacuate stool. The majority of patients undergoing TAR eventually need some form of irrigation or laxative treatment to improve continence. An evacuation training programme consisting of the application of enemas and suppositories at definite intervals may help to reduce incontinence [39].

When superiority of one treatment strategy over another is debated economics need also to be taken into consideration. It is unknown whether one procedure is more cost-effective than another. Approximations imply that TAR using DGP or ABS may prove to be cost-effective within 5 to 10 years after the operation. While the 5-year cumulative costs of a colostomy were calculated at 41,000 USD (34,000 Euros) [62], Eccersley and Williams suggested an undiscounted cost utility in the range of 10,000–20,000 USD per quality adjusted life year (QALY) gained by anorectal reconstruction. However, these calculations would need to be confirmed by a large-scale study.

Comparison and discussion of data from the analysed publications are hindered by the incongruence of scoring systems used, particularly concerning continence and QoL, and the variability or lack of sound definitions of outcome parameters applied, such as squeeze versus voluntary pressure. Furthermore, in many studies there was no assessment of preoperative QoL that could have been compared to postoperative values. In order to circumvent these limitations, the use of a standardised scoring system that ideally would be specific to TAR after APER, as proposed by Violi et al. [63], is recommended for future research. Given the majority of data in this field arising from case series, more high-quality trials (i.e. randomised, controlled) are warranted to gain better evidence concerning the ideal method of TAR.

It is clear that the optimal technique of TAR remains to be defined, and there is room for improvement. Intuitively, the optimal way to restore continent gastrointestinal continuity after APER might be to replace the excised organ by an anatomically and physiologically identical substitute. Substantial progress in the field of tissue engineering has brought this target closer to reality [64, 65]. A bioengineered faecal continence organ would have several advantages. First, it would work as an entity rather than a combination of different methods. That means avoidance of unnatural interfaces that may entail complications, such as colon necrosis due to compression by the mechanical sphincter device onto the perineal colon pull-through. Second, as it would be created out of organic material being immunologically identical to the host, it may be less prone to foreign body reactions and infection. Third, the implantation of a bioengineered continence organ could be performed in one stage without the need of re-interventions like the replacement of the cuff sizer by the ABS or extending the operative trauma to the site of

harvesting as for DGP, further minimising the overall risk of complications.

In summary, despite the refined surgical and oncological management of rectal cancer, a considerable number of patients have no option other than APER and a permanent abdominal colostomy. Where appropriate, reconstruction techniques may be applied. While oncologically safe, they are all associated with a considerable morbidity, and results of functional outcome and QoL are divergent. Regaining some sort of perception for the urge to defecate was shown to be essential for a good functional outcome, and hence, reasonable QoL. Furthermore, almost all patients after TAR need regular irrigation of the neo-anus in order to assist faecal evacuation and achieve a considerable level of continence. Not surprisingly, the best results of TAR are achieved by expert hands in specialised centres. Theoretical calculations suggest cost-effectiveness of TAR compared to abdominal colostomy is attained after APER within 5 to 10 years after reconstruction. While DGP and CSMC are by far the most frequently applied techniques for TAR, the optimal method has yet to be defined. In order to obtain more meaningful data and improve comparability of the studies on TAR, randomised trials rather than the currently available case series are warranted, and standardised questionnaires as well as evaluation score systems should be introduced. Significant progress in the field of tissue engineering may bring the dream of a tailored bioengineered continence organ whose anatomy and physiology resembles its archetype, closer to reality. Advances in the field of total anorectal reconstruction techniques would be of tremendous advantage. It may help thousands of patients every year to improve the quality of those life years gained after cure of the malignancy by radical surgery.

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