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ORIGINAL CONTRIBUTIONS

Single Anastomosis Duodeno-Ileal Switch (SADIS): A Systematic Review of Efficacy and Safety

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Abstract
Background Owing to the possibility of weight regain after the long-term follow-up of gastric bypass patients and because of the high morbidity of biliopancreatic diversion with duodenal switch, single-anastomosis duodeno-ileal switch (SADIS) has emerged as a rescue procedure in bariatric surgery.
Objective The purpose of this review is to summarize the literature data on SADIS.
Setting University Hospital, NY.
Methods A comprehensive literature review was performed through October 2016 to identify English studies on SADIS performed in human subjects. Outcomes of interest were technical considerations, postoperative complications, weight loss outcome, comorbidity resolution rate, and nutritional deficiency after SADIS.
Results A total of 12 studies including 581 SADIS patients (217 males and 364 females) were included. SADIS was a primary procedure in 508 patients (87.4%) and a conversion procedure in 73 patients (12.6%). The length of common limb was 300 cm in 54.2%, 250 cm in 23%, and 200 cm in 13.4% of patients. Anastomosis technique was a linear stapler in 26.7% and a hand sewn suture technique in 73.3% of patients. Diarrhea was the most common complication (1.2%). The average %EWL was 30% at 3 months, 55% at 6 months, 70% at 1 year, and 85% at 2 years. Co-morbidity resolution rate was 74.1% for type 2 diabetes mellitus, 96.3% for hypertension, 68.3% for dyslipidemia, 63.3% for obstructive sleep apnea, and 87.5% for GERD. Overall, vitamin A, selenium, and iron deficiency were the most common nutritional deficiencies with the possibility of the protein malnutrition in up to 34% of the patients when measured.
Conclusion As a modified bariatric procedure, SADIS has promising outcomes for weight loss and comorbidity resolution in morbidly obese patients. When measured, there was a high prevalence of macro-nutrient deficiencies following SADIS. There is a high technical variability, and long-term data are required before any meaningful conclusion can be made.

Keywords Single-anastomosis duodeno-ileal switch (SADIS) · Ileoduodenal switch · Duodeno-ileal bypass · Biliopancreatic diversion · Bariatric surgery · Systematic review

Introduction

Laparoscopic bariatric surgery has become the gold-standard treatment of morbid obesity [1, 2]. Although a recent meta-analysis has shown similar long-term outcomes for both the sleeve gastrectomy (SG) and Roux-en-Y gastric bypass (RYGB) [2], weight regain and comorbidities relapse prompted the bariatric surgeons to seek modification of currently established or introduction of new techniques [3]. Duodenal switch has proved to be the most effective procedure in terms of the long-term weight loss outcome and co-morbidity resolution. However, its technical difficulty and potential adverse events have limited its widespread use [4].

Single-anastomosis duodeno-ileal switch (SADIS) is a modification of the original biliopancreatic diversion with duodenal switch (BPDDS) [5]. Due to its simpler technique and reduced number of anastomosis, SADIS has shown potentials

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in bariatric surgery [6]. Currently, there are case series with limited follow-up on postoperative outcome of patients undergoing this new procedure [6–19]. Our systematic review aimed to pool available data in the literature on weight loss outcome and co-morbidity resolution as well as postoperative complication and nutritional deficiency in patients undergoing SADIS for morbid obesity.

Methods

Review Design

In adherence to the preferred reporting items for systematic reviews and meta-analyses (PRISMA) guidelines [20], a systematic review was designed using the Cochrane handbook for systematic reviews of interventions [21]. Two independent reviewers reviewed the literature and retrieved the full texts of the eligible papers for data extraction. Any conflict was resolved by consensus.

Search Strategy

PubMed/Medline, ISI Web of Science, and Scopus were queried through July 2016 using the following combination of keywords: [("single anastomosis" or "single-anastomosis") and ("ileoduodenal" or "duodenoileal" or "duodeno-ileal" or "duodenal" "ileo-duodenal")] or [("stomach intestinal pylorus sparing" or "SIPS")]. Manual screening of the bibliography of the retrieved papers was also performed to supplement our search protocol.

Study Selection

English papers reporting the outcomes of a single-anastomosis duodeno-ileal bypass procedure for weight loss in human were included. Review articles, commentaries, and surgical technique descriptions were excluded.

Data Extraction and Analysis

The primary endpoint of this study was the efficacy of SADIS in treatment of morbid obesity, defined as the weight loss outcome and comorbidity resolution. The secondary endpoint was the safety of SADIS, defined as the incidence rate of postoperative complications and nutritional deficiencies.

Extracted data were pooled to estimate an overall result on weight loss outcome, comorbidity resolution rate, and the incidence of postoperative technical and metabolic complication. The values are presented as mean ± standard deviation (SD) or number (percentage, %).

Results

Search Result

A total of 117 records were identified through initial literature search. Additionally, 11 papers were identified by manual search of the supplementary sources. After duplicate removal and title/abstract screening, full-texts of 34 articles were reviewed. Of these, 14 papers [5–18] were eligible of which two papers [5, 14] were excluded from quantitative analysis due to overlapping data on the same group of patients (Fig. 1). Publication time frame ranged from 2013 to 2016 with the majority of the SADISs performed in 2015 (280 patients, 48.2%), 2016 (181 patients, 31.1%), and 2013 (100 patients, 17.2%) (Fig. 2).

Characteristics of Included Studies and SADIS Patients

Twelve eligible studies comprised five cohorts [6–8, 13, 18], four case series [9–12], and three case reports [15–17] encompassing a total of 581 SADIS patients (217 males and 364 females). Patients' age and BMI ranged between 18 and 71 years and 33–71.5 kg/m^2. Of 581 SADIS surgeries, 508 (87.4%) were a primary and 73 (12.6%) were a revision procedure. T2DM (354 patients, 60.1%), HTN (286 patients, 49.2%), and GERD (136 patients, 23.4%) were the most common reported comorbidity in SADIS patients. Follow-up was available between 6 and 60 months after SADIS (Table 1).

Technical Considerations of SADIS According to Different Studies

SADIS was variably named in different studies as stomach intestinal pylorus sparing (SIPS) surgery (258 patients, 44.4%) [8, 12, 13, 15], single anastomosis duodeno-ileal bypass with sleeve (SADI-S) (197 patients, 33.9%) [6, 9], single anastomosis loop duodenal switch (SALDS) (57 patients, 9.8%) [16, 17], single anastomosis duodenal-jejunal bypass with sleeve gastrectomy (SADJB-SG) (50 patients, 8.6%) [7], and single anastomosis duodeno-ileal bypass (19 patients, 0.3%) [16] (Table 2).

Length of common limb was reported by nine studies (528 patients, 90.9%) [6, 8–13, 17, 18]. Of these, the common limb was 300 cm in 315 patients (54.2%), followed by 250 cm and 200 cm in 135 (23.2%) and 78 (13.4%) patients, respectively. Similarly, bougie size was reported by ten studies (560 patients, 96.4%) [6–10, 12, 13, 15, 17, 18]. Of these, bougie size 42 (252 patients, 43.4%) and 54 (197 patients, 33.9%) were the most common ones to be used.

Anastomosis technique was described by eight studies (564 patients, 97%). Of these, linear stapler was used in three studies (151 patients, 26.7%) [6, 7, 17] but a hand sewn suture technique in seven studies (413 patients, 73.3%) [6, 8, 11–13, 15, 18]. Only two studies (113 patients, 19.4%) reported the hand sewn or linear stapler [9, 10]. Additionally, two studies (150 patients,

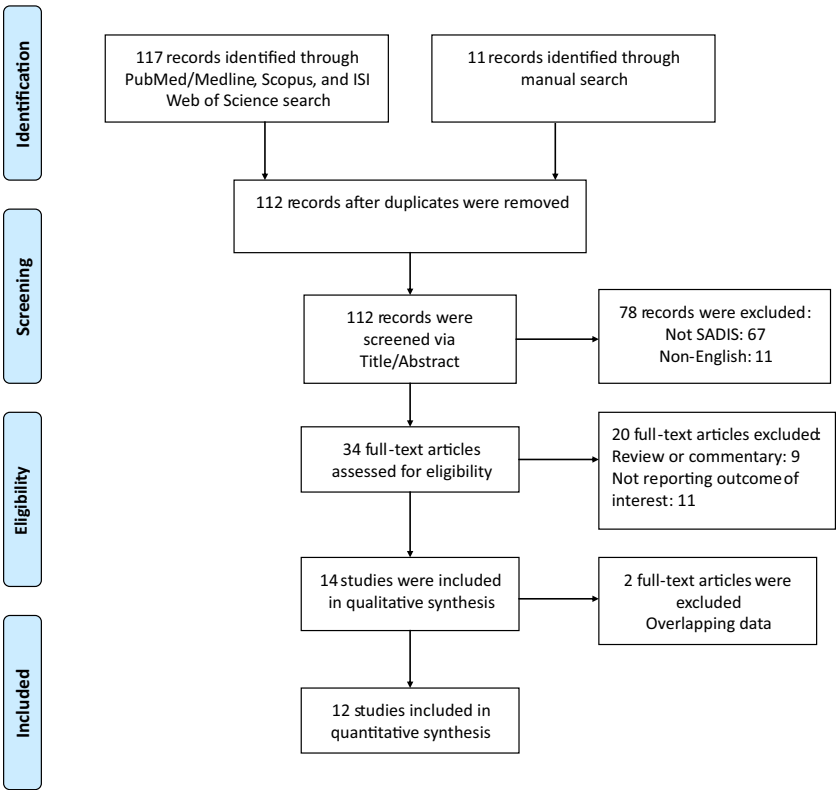

Fig. 1 PRISMA flowchart for this systematic review search protocol

25.8%) stated the reinforcement of the staple line in the sleeve invagination (100 patients, 66.7%) [7] and staple line (50 patients, 33.3%) [6].

Postoperative Complications

Sixteen types of complications were reported postoperatively by the included studies in 28 patients. The overall complication rate following SADIS was 4.8%. Diarrhea was the most common complication (six patients, 1.2%) reported by three studies (188 patients) [8, 12, 18] (Table 3). However, diarrhea in one patient was due to clostridium difficile [12]. Other complications included staple line leak, anastomosis leak, wound infection, dysphagia, sleeve stricture, bowel obstruction, gastro-esophageal reflux disease each in two patients (0.34%) and abscess, incisional hernia, hemoperitoneum, postoperative bleeding, internal hernia, umbilical hernia, and ileus each in one patient (0.17%). The average number of bowel movements was reported by three studies (213 patients, 36.6%) ranging between 2.1 and 2.5 times per day [8, 12, 18].

Co-morbidity Resolution

Co-morbidity resolution was observed in 183 patients out of 247 ones with T2DM (74.1%), 131 patients out of 136 ones

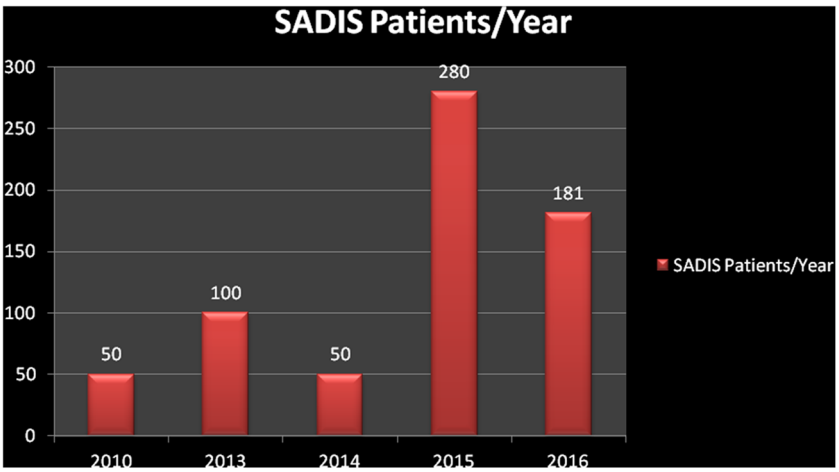

Fig. 2 Number of overall SADIS performed per year

Table 1 Characteristics of included studies on single-anastomosis duodeno-ileal switch (SADIS)

Author/year	Type of study	Sample size	Gender (M:F)	Age	Initial BMI	Type of surgery	Follow-up
Cottam/2016	Retrospective cohort	54	16:38	51.9 ± 13	47.6 ± 8.8	Primary	18 months
Summerhays/2016	Case report	1	0:1	35	?	Revision	2 months
Mitzman/2016	Retrospective	123	45:78	50 ± 13.1	49.4 ± 9.2	Primary	1 year
Surve/2016	Case report	2	0:2	32–41	41.2–71.5	Primary or revision	1 month
Surve/2016	Video report	1	0:1	65	38	Primary	6 months
Roslin/2015	Retrospective	129	45:84	49.98 ± 12.86	49.72 ± 9.65	Primary	12 months
Sánchez-Pernaute/2015	Case series	16	4:12	42 (18–62)	56.4 (41–71.5)	Second step after sleeve gastrectomy	21 months (2–46)
Sánchez-Pernaute/2015	Case series	97	45:52	50	44.3	Primary (52) or second (45) step	5 years
Vilallonga/2015	Case series	3	3:0	34–59	49.87–57.66	Revision	9 months
Zaveri/2015	Case series	5	3:2	59.6 ± 16.4	43.3 ± 6.3	Primary	1 year
Lee/2014	Prospective	50	19:31	45 ± 8.7	38.4 ± 6	Primary	12 months
Sánchez-Pernaute/2013	Retrospective	100	37:63	47 (22–71)	44.6 (33–67)	Primary (93) or second step (7)	48 months
2013–2016	Cohort: 5 Case series: 4 Case report: 3	581	217:364	18–71	33–71.5	Primary: 508 Revision: 73	6–60 months

M:F male to female ratio, *BMI* body mass index

with HTN (96.3%), 69 patients out of 101 ones with dyslipidemia (68.3%), 19 patients out of 30 ones with OSA (63.3%), and 7 patients out of 8 ones with GERD (87.5%) (Table 4).

Weight Loss Outcome

Weight loss was reported by nine studies (575 patients, 98.9%) at variable time intervals after the surgery [6–10, 12, 13, 15, 18]. The maximum reported %EWL was 49% at 3 months (17.8–49%), 80% at 6 months (41–80%), 95% at 1 year (63.2–95%), and 100% at 2 years (72–100%) (Table 5). On the other hand, the average %EWL was 30% at 3 months (17.8–49%), 55% at 6 months (41–80%), 70% at 1 year (63.25–95%), and 85% at 2 years (72–100%) (Fig. 3 and Table 5).

Nutritional Disturbances

Nutrient deficiencies were inconsistently reported in the literature and only by four of our included studies (213 patients, 36.6%) [6, 9, 10, 18]. Selenium, zinc, and iron were the most common deficient minerals (in up to 50% of the reported cases), vitamin A deficiency in up to 53% of the reported patients, and protein deficiency in up to 34% of patients (Table 6). Overall, vitamin A, selenium, and iron deficiency were the most common nutritional disturbances after SADIS (Fig. 4).

Revisional vs. Primary SADIS

There was no technical difference between the primary or the revisional SADIS in terms of the length of the efferent limb, bougie size, and the stapler type used for duodeno-ileal anastomosis (Table 2). On the other hand, staple line leak, wound infection, diarrhea, dysphagia, upper GI bleeding, hemoperitoneum, internal herniation, GERD, and bowel obstruction were more commonly reported with the revisional SADIS. There was no sufficient data to comment on any potential difference between these types of SADIS in terms of weight loss, comorbidity resolution, or nutritional deficiencies.

Discussion

SADIS was introduced in 2007 by Sánchez-Pernaute as a modification of biliopancreatic diversion with duodeno-ileal switch (BPDDS) in which after sleeve gastrectomy, the duodenum is anastomosed to an ileal loop in a Billroth-II fashion [4]. Although the authors reported the first clinical outcome of SADIS later in 2010 [5], a series of studies were successively published on the utility and feasibility of this new technique [5–18]. Numerous terms have been used for SADIS, including single-anastomosis duodenal-jejunal bypass, single anastomosis loop duodenal switch, single-anastomosis duodeno-ileal bypass with sleeve gastrectomy, stomach intestinal pylorus sparing surgery, and single-anastomosis duodeno-ileal switch,

Table 2 Technical considerations of SADIS

Author/year	Procedure name	Length of efferent limb (cm)	Bougie size (F)	Duodeno-ileal anastomosis	
				Linear stapler	Hand sewn
Cottam/2016	SALDS	300	40	NA	+
Summerhays/2016	SALDS	300	40	+	NA
Mitzman/2016	SIPS	300	42	NA	+
Surve/2016	SALDS	NA	NA	NA	NA
Surve/2016	SIPS	NA	40	NA	+
Roslin/2015	SIPS	300	42	NA	+
Sánchez-Pernaute/2015	SADI	250	42–54	+/−	+/−
Sánchez-Pernaute/2015	SADI-S	200 (28 cases), 250 (69 cases)	54	+/−	+/−
Vilallonga/2015	Robotic SADI	300	NA	NA	+
Zaveri/2015	SIPS	300	40	NA	+
Lee/2014	SADJB-SG	NA	45	+	NA
Sánchez-Pernaute/2013	SADI-S	250 (50 cases), 200 (50 cases)	54	+	+
Total	Total: 581	Reported: 528	Reported: 560	Reported: 151	Reported: 413
	SIPS: 258	200: 78	40: 61		
	SADI-S: 197	250: 135	42: 252		
	SALDS: 57	300: 315	45: 50		
	SADJB-SG: 50		54: 197		
	SADI: 19				

CM centimeter, *SIPS* stomach intestinal pylorus sparing surgery, *SADI-S* single anastomosis duodeno-ileal bypass with sleeve, *SALDS* single anastomosis loop duodenal switch, *SADJB-SG* single anastomosis duodenal-jejunal bypass with sleeve gastrectomy, *SADI* single anastomosis duodeno-ileal bypass, *NA* not available, +/− either linear stapler or hand sewn was used, *A* anastomosis line, *S* staple line

all simply refer to a pylorus sparing technique gastrectomy accompanied by a proximal duodenal-ileal end-to-side bypass.

Our systematic review of 581 SADIS patients (508 primary and 73 conversion procedures) demonstrated the evolution of SADIS technique from inception over the last decade. Currently, follow-up data on SADIS outcome is available up to 60 months after the surgery. Little data is available on durability of SADIS in weight loss outcome and comorbidity resolution as well as long-term development of postoperative complications.

Technical Considerations

Almost a decade has passed since the introduction of SADIS to bariatric surgery during which surgeons have adopted a longer efferent limb [14–16, 18] by creating a shorter afferent limb. The modification occurred as a result of early postoperative complication and late nutritional deficiency [8, 17, 18]. A similar trend was noted over time for bougie size decreasing from 54 French [6, 9, 10] to 40 French. Having only one anastomosis makes SADIS more feasible technically than the classical duodenal switch with two anastomoses.

Postoperative Complications

Although SADIS has been developed to simplify the technique for BPDDS, it still bears the complications of a combined restrictive and malabsorptive procedure. Postoperative staple line leak, anastomosis leak, bleeding, hernia, infection and abscess formation, ileus, bowel obstruction, and diarrhea are among the reported early postoperative complications [4–14, 16–18]. Our review determined diarrhea as the most common complication after SADIS. On average, SADIS patients experience up to three bowel movements per day [6, 9, 10, 14, 18]. This is much lower than the number of bowel movements reported by patients after BPDDS [21, 22]. In a matched comparison of SADIS and RYGB, Cottom et al. showed that diarrhea/steatorrhea in SADIS patients occurs as a result of a miscounted alimentary loop, resembling the length of a common limb in the traditional BPDDS [18]. Subsequently, the diarrhea was resolved after lengthening of the loop to a 450 cm common channel. In our review, the

Table 3 Postoperative complications after SADIS

	Frequency	Reference	Duration of follow-up
Staple line leak	2/100	Sánchez-Pernaute (2013)	48 months
Anastomosis leak	2/197	Sánchez-Pernaute (2015 and 2013)	21 to 48 months
Wound infection	2/104	Cottom (2016); Lee (2014)	12 to 18 months
Abscess	1/129	Roslin (2015)	12 months
Diarrhea	6/188	Cottom (2016); Roslin (2015); Zaveri (2015)	12 to 18 months
Dysphagia	2/134	Roslin (2015); Zaveri (2015)	12 months
Upper gastrointestinal bleeding	1/100	Sánchez-Pernaute (2013)	48 months
Incisional hernia	1/100	Sánchez-Pernaute (2013)	48 months
Hemoperitoneum	1/97	Sánchez-Pernaute (2015)	2 to 46 months
Postoperative bleeding	1/54	Cottam (2016)	18 months
Internal hernia	1/1	Summerhays (2016)	2 months
Sleeve stricture	2/54	Cottam (2016)	18 months
Bowel obstruction	2/2	Surve (2016)	1 to 6 months
Umbilical hernia	1/97	Sánchez-Pernaute /2015	2 to 46 months
Ileus	1/5	Zaveri (2015)	12 months
Gastroesophageal reflux	2/5	Zaveri (2015)	12 months
Overall	28 (4.8%)		

average number of bowel movements was reported between 2.1 and 2.5 per day [8, 12, 18].

Weight Loss Outcome

The pooled percentage of excess weight loss after SADIS ranges from 17.8% in the first 3 months up to 100% after 2 years. SADIS has shown comparable weight loss to that of RYGB [18] but a superior effect than LSG [14]; however, no study has compared its efficacy against the traditional BPDDS. It is explained that early weight loss occurs due to the creation of the restrictive slim tube while the sustained weight loss is a result of the malabsorptive component. Only two studies are available with a follow-up longer than 2 years, demonstrating a sustainability of 72–95% of %EWL after the SADIS as a second step of weight loss surgery after the

Table 4 Comorbidity resolution in patients of the included studies

Author/year	Postoperative resolution/preoperative comorbidities				
	T2DM	HTN	Dyslipidemia	OSA	GERD
Cottam/2016	22/31	NA/34	0/0	NA/31	NA/34
Summerhays/2016	NA	NA	NA	NA	NA
Mitzman/2016	NA/55	NA/60	0/0	NA/60	NA/47
Surve/2016	0/0	2/2	1/1	0/2	1/2
Surve/2016	0/0	0/0	0/0	0/0	1/1
Roslin/2015	NA/52	NA/56	0/0	NA/60	NA/47
Sánchez-Pernaute/2015	8/9	9/10	10/10	0/0	0/0
Sánchez-Pernaute/2015	48/97	63/66	25/32	NA	NA
Vilallonga/2015	1/1	1/1	1/1	1/1	0/0
Zaveri/2015	NA	NA	NA	NA	5/5
Lee/2014	50/50	NA	NA	NA	NA
Sánchez-Pernaute/2013	54/59	56/57	32/57	18/27	NA
Comorbidity	354	286	101	181	136
Resolution/improvement rate	183/247 (74.1%)	131/136 (96.3%)	69/101 (68.3%)	19/30 (63.3%)	7/8 (87.5%)

T2DM type 2 diabetes mellitus, *HTN* hypertension, *OSA* obstructive sleep apnea, *GERD* gastroesophageal reflux disease, *NA* not available

Table 5 Postoperative weight loss outcome (%EWL) after SADIS

Author/year	Preoperative BMI (*N* = 580)	3-month post-op (*N* = 312)	6-month post-op (*N* = 425)	12-month post-op (*N* = 451)	2-year post-op (*N* = 127)
Cottam/2016	46.18 ± 7.56	49%	71.4%	86.5%	NA
Summerhays/2016	NA	NA	NA	NA	NA
Mitzman/2016	50.5	33%	54%	NA	NA
Surve/2016	41.2–71.5	NA	NA	NA	NA
Surve/2016	38	38.4%	45%	NA	NA
Roslin/2015	49.6	17.8%	41.67%	63.25%	NA
Sánchez-Pernaute/2015	56.4	NA	62.5%	68.6%	72%
Sánchez-Pernaute/2015	44.3	NA	73%	91%	92%
Vilallonga/2015	34.3–46.5	NA	NA	NA	NA
Zaveri/2015	43.4 ± 6.3	29.9 ± 5.8%	47.9 ± 8%	73.5 ± 5.3%	84.2 ± 3.4%
Lee/2014	38.4	NA	NA	80.3%	NA
Sánchez-Pernaute/2013	44.6 (first step), 48.5 (2nd step)	NA	80%	95%	100%
Overall	34.3–71.5	17.8–49%	41–80%	63.25–95%	72–100%

BMI body mass index, *%EWL* percent of excess weight loss, *Post-op* postoperative, *NA* not available

primary sleeve gastrectomy [6, 10]. In comparison, revisional BPDDS after a failed RYGB has shown a %EWL of 29.2% at 2-year follow-up [23]. Nevertheless, SADIS data on the long-term weight loss is lacking and only 127 patients have a minimum of 2-year follow-up.

Comorbidity Resolution

Our pooled analysis revealed a resolution rate of 74.1% and 96.3% for T2DM and HTN, respectively. For other obesity comorbidities, SADIS achieved a resolution rate of > 60%. The superiority of BPDDS than that of other bariatric procedures in comorbidity resolution has been well established by previous meta-analysis [2, 24]. Rapid transition of gastric content into the small bowel and early exposure to the terminal segment of the gastrointestinal tract has been accounted responsible for incretin secretion [1]. This is responsible for the discrete effect of bypassed GI route, besides the weight loss effect, in improvement of insulin resistance and post-prandial glucose. On the other hand, it seems that the resolution of other comorbidities such as HTN, HLP, and OSA is more compatible with the weight loss pattern after duodeno-ileal bypass.

Nutritional Deficiency

Nutritional deficiency is directly correlated with the length of the common alimentary limb in duodeno-ileal switch [25]. Although Vitamin A and D deficiency, anemia, and hyperparathyroidism secondary to a Vitamin D deficiency and hypocalcaemia are among the most common nutritional disturbance after a BPD/DS [26], our review also identified selenium and protein deficiency in up to 50% and 34% of SADIS patients, respectively. Compared to a traditional BPDDS with a common limb of

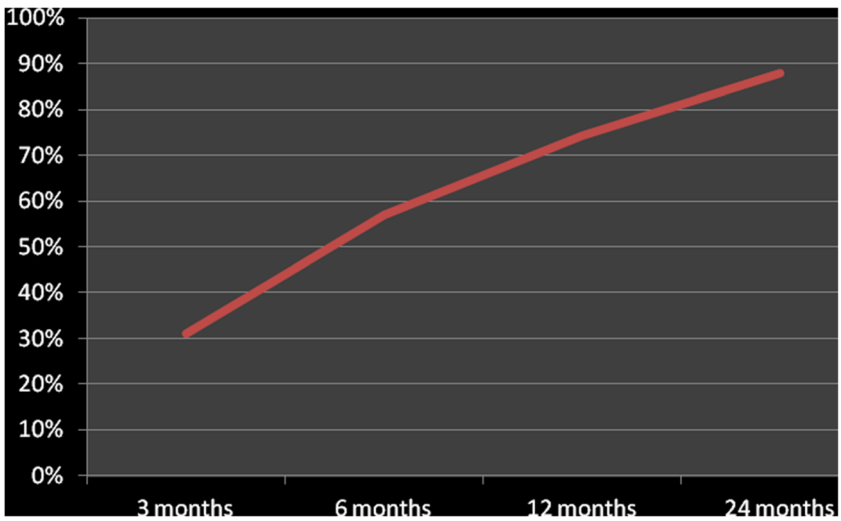

Fig. 3 Pattern of %EWL at different time intervals after SADIS

Table 6 Nutritional deficiency after SADIS

Author	Post-op year	Protein deficiency	Albumin deficiency	Vitamin deficiency						Minerals				No. of BM
				A	D	E	K	B_{12}	Folate	Zn	Fe	Cu	Se	
Cottam/2016	1st	8% (3/37)	11% (4/37)	NA	31% (12/35)	NA	NA	29% (10/34)	16% (5/32)	NA	NA	NA	NA	NA
Summerhays/2016	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Mitzman/2016	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Surve/2016	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Surve/2016	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Roslin/2015	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sánchez-Pernaute/2015	2nd	18%	0%	25%	6% def. 50% ins	0%	NA	6%	6%	31%	50%	12%	50%	2.5
Sánchez-Pernaute/2015	1st	34%	13.7%	44%	15% def. 35% ins	0%	NA	8%	8%	17%	NA	13%	29%	2.1
	3rd	29%	12%	53%	23% def. 23% ins	7%		8%	3%	33%		11%	28%	
Vilallonga/2015	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Zaveri/2015	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Lee/2014	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sánchez-Pernaute/2013	2nd	16%	6%	NA	6% def. 40% ins	NA	NA	20%	10%	NA	4%	NA	NA	2.5
Total	1st–3rd	8–34%	6–13.7%	25–53%	6–31%	0–7%	NA	6–29%	6–16%	4–50%	4–50%	11–13%	28–50%	2.1–2.5

Def deficiency, *Ins* insufficiency, *NA* not available, *A* vitamin A, *D* vitamin D, *E* vitamin E, *K* vitamin K, *B_{12}* vitamin B_{12}, *Zn* zinc, *Fe* iron; *Cu* cupper, *Se* selenium, *No BM* number of bowel movements

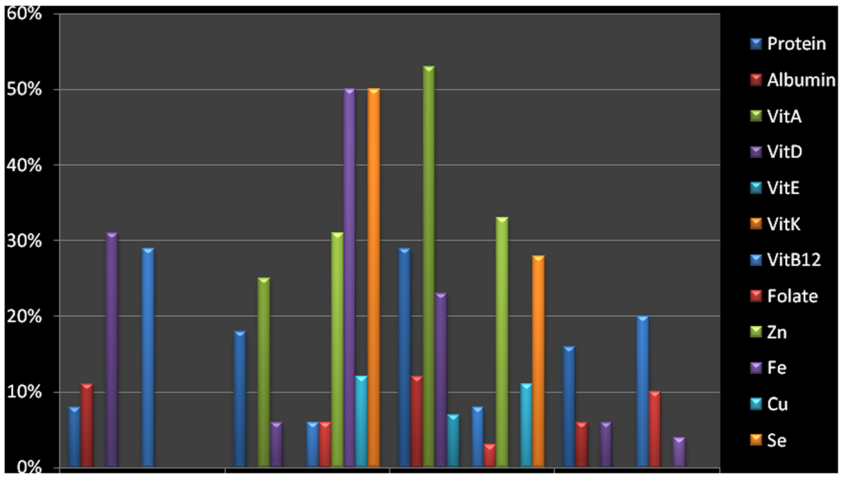

Fig. 4 Nutrient deficiency at the longest follow-up after SADIS

100 cm, a modified procedure with a longer loop of 200 cm or more, as is in SADIS, can result in similar weight loss and comorbidity resolution but potentially a lower rate of protein deficiency, micronutrient disturbance, and lower amount of prescribed vitamin A and D [14, 18, 25]. The benefits of a longer common limb in reduction of the nutrient deficiency after SADIS can be observed in the study of Cottom et al. implementing a 300-cm loop [18]. The authors reported a significantly lower rate of micronutrient and vitamin deficiency, while still achieving a %EWL of 86% at 12 months. Unfortunately, this is the only study on SADIS with a long common limb (> 200 cm) which dynamically investigated the frequency of postoperative micronutrient deficiency. Additionally, follow-up of SADIS patients in terms of nutritional and metabolic disturbance is still premature.

Limitations and Perspectives for Future Studies

This is the first systematic review on SADIS demonstrating where we stand on our way toward a modified rescue procedure in bariatric surgery. Although the pooled results collectively support the efficacy and safety of this SADIS in the treatment of morbid obesity, the technique is evolving in terms of malabsorptive and restrictive component. On the other hand, authors have repeatedly published overlapping data of patients undergoing SADIS, in forms of case reports and small case series, for which stratification and meta-analysis seem impractical. Additionally, mid-term and long-term outcomes of SADIS in comparison to the currently established procedures are not available. Future randomized controlled trials are warranted to compare SADIS outcome in terms of weight loss and co-morbidity resolution with commonly performed RYGB and LSG.

Conclusion

As a modification of traditional BPDDS, SADIS is a bariatric procedure with a combined restrictive and malabsorptive components. SADIS showed a promising short-term weight loss outcome and comorbidity resolution rate. Moreover, postoperative complications and nutritional deficiencies are comparable to the BPDDS but long-term data are missing and there is currently a high level of technical variability. On the other hand, further studies are required to measure its cost-effectiveness compared to the currently popular bariatric procedures, LSG and RYGB.

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Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflict of interest.

Statement of Informed Consent N/A

Statement of Human and Animal Rights N/A

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