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ORIGINAL CONTRIBUTIONS

Revisional Bariatric Surgery in Israel: Findings from the Israeli Bariatric Surgery Registry

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Abstract

Background Bariatric surgery (BS) is a proven sustainable approach for obesity, and its frequency is increasing worldwide. However, the frequency of revision surgery (RS) is also increasing. This study aimed to evaluate the RS rate in Israel and compare RS to primary surgery (PS).

Methods Data were obtained from the Israeli Bariatric Surgery Registry. All patients aged > 18 years who underwent BS between June 2013 and December 2016 were considered for inclusion. Sociodemographic and clinical data were analyzed.

Results PS was performed in 28,707 patients and RS was performed in 4026 patients. The mean body mass index values were 42.1 ± 5.0 and 41.3 ± 7.0 kg/m^2 in the PS and RS groups, respectively. Hypertension, type 2 diabetes mellitus, dyslipidemia, and fatty liver were less frequent in the RS group than in the PS group. The percentage total weight loss (%TWL) values 6 months and 1 year postoperatively were 25.1 ± 8.1% and 30.5 ± 9.5%, respectively, in the PS group and 18.5 ± 8.9% and 23.12 ± 11.4%, respectively, in the RS group ($P < 0.001$). Complications were noted in 856 (3.5%) and 210 (6.2%) patients from the PS and RS groups, respectively. A multilinear regression model found that more weight loss was significantly associated with RS type (revision bypass vs. revision restrictive surgery).

Conclusions The RS rate is continuously increasing, and it should be tapered according to indications and feasibility. Our findings indicate that RS can be performed with acceptable complication rates and that restrictive surgery should be converted to bypass surgery to achieve acceptable weight loss with fewer complications.

Keywords Bariatric surgery · Revisional surgery · Bariatric surgery registry

Introduction

Bariatric surgery (BS) is a well-proven sustainable approach for the management of obesity and its comorbidities, and its frequency is increasing worldwide [1, 2]. Studies have shown that weight regain after BS ranges from 5 to 39%, depending on the type of surgery and patient compliance, and a significant proportion of patients undergo revision surgery (RS) [3–6]. The proportion of patients needing revision after weight loss surgery can approach 25% and might reach 60% for certain procedures [7–9].

The Israeli Bariatric Surgery Registry (ISBR) started collecting data from 2013, and currently, it is required to report all BS procedures in Israel to the registry. The aim of the present study was to evaluate the RS rate in Israel and compare RS to primary surgery (PS), using this registry. Additionally, a literature review was performed to compare registry and other published data.

Methods

Data were obtained from the ISBR. All hospitals performing BS are obligated to submit specific data to the registry. The

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data collected for this study included patent sociodemographic and clinical data. Information on the vital status was obtained in August 2017, by cross-referencing mortality information from the population register. The present study was approved by the regional ethics board.

All patients aged > 18 years who underwent BS in Israel between June 2013 and December 2016 were considered for inclusion in this study. The body mass index (BMI), percentage of weight loss (%WL), and percentage of excess weight loss (%EWL) were calculated. We used the ideal body weight considering a BMI of 25 kg/m^2 to calculate the %EWL.

Data are expressed as mean ± standard deviation (SD) or percentage. Differences in mean values between PS and RS were assessed using the independent samples *t* test for continuous variables and the chi-squared test for categorical variables. All statistical analyses were performed using the SAS package (version 9.1, SAS Inc., Cary, NC, USA). A P value < 0.05 was considered statistically significant for all analyses.

Associations between independent variables and %EWL 1 year after BS (as a continuous variable) were analyzed using simple linear regression models. Variables indicating statistically significant associations with %EWL 1 year after BS ($P < 0.05$) were included in multiple linear regression models.

Results

The demographics of patients in the PS and RS groups are presented in Table 1. There were 28,707 patients in the PS group and 4026 patients in the RS group. A total of 75 patients were excluded from the analysis, as previous BS data were missing. The mean patient ages and male percentages were 41.5 ± 12.7 years and 33.4% in the PS group and 44.2 ± 11.5 years and 26.5% in the RS group, respectively. Additionally, the mean BMI values and numbers of patients with BMI ≥ 50 kg/m^2 were 42.1 ± 5.0 kg/m^2 and 2054 (4.6%) in the PS group and 41.3 ± 7.0 kg/m^2 and 437 (10.9%) in the RS group, respectively. These values were all significantly different between the groups. The proportions of patients with hypertension, type 2 diabetes mellitus, dyslipidemia, and fatty liver were significantly lower in the RS group than in the PS group. On the other hand, the proportion of patients with sleep apnea was significantly higher in the RS group. Other comorbidities showed no significant differences between the groups. The proportions of patients with different numbers of comorbidities significantly differed between the groups.

Table 2 presents the types of procedures and operative data. In the PS and RS groups, 1974 (6.9%) and 644 (16%) patients underwent gastric band surgery, 22,754 (79.3%) and 1479 (36.7%) underwent sleeve gastrectomy (SG), and 3788 (13.2%) and 1728 (42.9%) underwent bypass procedures, respectively. The distribution of the types of surgeries was significantly different between the groups ($P < 0.0001$). The revision indications were weight regain in 2009 (94.7%) patients and complications in 113 (5.3%) patients. The surgical approach was primarily laparoscopic in 24,357 (99.5%) and 3274 (96.8%) patients from the PS and RS groups, respectively. Primarily, open surgery was performed in 61 (0.25%) and 79 (2.3%) patients and laparoscopic surgery was converted to open surgery in 59 (0.25%) and 30 (0.9%) patients from the PS and RS groups, respectively. Hospital stay was 2.7 ± 2.7 and 3.2 ± 5.2 days in the PS and RS groups, respectively ($P < 0.0001$).

Table 3 presents the outcomes and laboratory data. The percentage total weight loss (%TWL) values 6 months and 1 year postoperatively were 25.1 ± 8.1% and 30.5 ± 9.5%, respectively, in the PS group and 18.5 ± 8.9% and 23.12 ± 11.4%, respectively, in the RS group ($P < 0.001$). Complications were noted in 856 (3.5%) and 210 (6.2%) patients from the PS and RS groups, respectively ($P < 0.0001$). All complications, except bleeding, were significantly more frequent in the RS group than in the PS group. Death occurred in 108 (0.4%) and 20 (0.2%) patients from the PS and RS groups, respectively ($P < 0.0001$).

Table 4 presents the RS type according to the PS type, exhibiting a significant difference in the distribution ($P < 0.0001$).

Table 5 presents the multilinear regression model for factors associated with %EWL 1 year after RS in patients who underwent restrictive PS (gastric banding and SG). Old age, male sex, and high BMI before surgery were significantly associated with less weight loss, whereas current smoking, population type (Jews vs. Arabs), and RS type (revision bypass vs. revision restrictive surgery [banding or SG]) were significantly associated with more weight loss.

Conclusion

It is well known that BS is effective in the long-term management of weight loss and comorbidity improvement [10]. The frequency of revision procedures is increasing, although they are known to be less effective and associated with complications [11–13]. The 2016 International Federation for the Surgery of Obesity and Metabolic Disorders (IFSO) stated that RS accounted for 7.4% of all bariatric procedures globally [14].

Demographic data indicated that most BSs were performed in female patients, with a higher proportion of female patients than male patients in the RS group as noted in different literature reviews [9, 15]. RS patients were significantly older as reported in the literature [16, 17].

The mean pre-surgical BMI was lower in the RS group than in the PS group, as indicated by other reviews comparing primary surgery with revision Roux-en-Y gastric bypass (RYGB) or SG [15]. Our study found that patients who underwent RS had less comorbidities when compared with

Table 1 Patient demographic and clinical characteristics in the primary and revision bariatric surgery groups

Characteristics	Primary surgery *N* = 28,707 *N* (%) or mean ± SD	Revision surgery *N* = 4026 *N* (%) or mean ± SD	*P* value
Demographic data			
Sex (male)	9597 (33.4)	1067 (26.5)	< 0.0001
Age (years, mean ± SD)	41.5 ± 12.7	44.2 ± 11.5	< 0.0001
Ethnicity			
Jews	23,823 (83.0)	3518 (87.4)	< 0.0001
Arabs	4884 (17.0)	508 (12.6)	
Marital status (married)	12,706 (44.3)	1977 (49.6)	< 0.0001
Current smoker	5748 (22.5)	783 (23.2)	0.07
	N = 24,320	*N* = 3372	
Past smoker	2584 (19.6)	310 (16.0)	< 0.0001
	N = 13,198	*N* = 586	
Anthropometric data			
BMI (kg/m^2, mean ± SD)	42.1 ± 5.0	41.3 ± 7.0	< 0.0001
BMI ≥ 50 kg/m^2	2054 (4.6)	437 (10.9)	< 0.0001
Pre-surgical comorbidities			
Hypertension	7264 (29.9)	878 (26.8)	< 0.0002
	N = 24,265	*N* = 3281	
Type 2 diabetes	6460 (26.7)	634 (19.4)	< 0.0001
	N = 24,238	*N* = 3272	
Orthopedic problems	3420 (14.1)	440 (9.4)	< 0.3223
	N = 24,196	*N* = 3261	
Sleep apnea	3463 (14.4)	308 (19.4)	< 0.0001
	N = 24,132	*N* = 3262	
Ischemic heart disease	425 (3.3)	66 (3.3)	< 0.9101
	N = 12,710	*N* = 2003	
Dyslipidemia	4778 (35.4)	591 (28.4)	< 0.0001
	N = 13,484	*N* = 2083	
Fatty liver	8477 (62.9)	955 (46.6)	< 0.0001
	N = 13,475	*N* = 2049	
Previous stroke	185 (0.8)	29 (0.9)	0.5400
	N = 24,155	*N* = 3259	
Atherosclerosis	1050 (4.3)	128 (3.9)	0.2670
	N = 24,225	*N* = 3269	
No. of comorbidities (%)			
0–1	12,735 (52.1)	1950 (58.7)	< 0.001
	N = 24,448	*N* = 3321	
2–3	8244 (33.7)	966 (29.1)	
> 3	3469 (14.2)	405 (12.2)	
Length of follow-up (months)	22.6 ± 12.4	20.3 ± 12.5	0.3855

SD standard deviation, *BMI* body mass index

patients who underwent PS. Similarly, other studies have reported significantly less comorbidities in the RS group when compared with the PS group [16, 18]. There are very few studies addressing the issue of comorbidities and RS, with various results. A Swedish group reported an increase in comorbidities in the RS group [19].

RS indications include inadequate weight loss, weight regain, and complications. Patients undergoing revisional surgery due to weight issues must have a BMI over 35. All RS patients must attend a special revisional bariatric committee, which includes besides the regular committee (surgeon, dietician, and psychologist) an additional physician (bariatric surgeon, gastroenterologist, or endocrinologist). After meeting separately with all committee members, the committee assembles and jointly approves or disapproves the patient for revisional surgery.

The IFSO 2016 report stated that 26% of RSs are associated with complications, 63% are associated with inadequate

Table 2 Bariatric surgical procedures and operative data in the primary and revision surgery groups

Characteristics	Primary surgery $N = 28,707$ N (%) or mean ± SD	Revision surgery $N = 4026$ N (%) or mean ± SD	P value
Type of surgery			
Gastric banding (LAGB)	1974 (6.9)	644 (16.0)	< 0.0001
Sleeve gastrectomy (LSG)	22,754 (79.3)	1479 (36.7)	
Roux-en-Y gastric bypass/omega loop mini	3788 (13.2)	1728 (42.9)	
Others (duodenal switch [BPD-DS], Scopinaro procedure [BPD], vertical banded gastroplasty, one anastomosis duodenal switch)	191 (0.7)	175 (4.4)	
Indication			
Weight loss	13,056 (100)	2009 (94.7)	< 0.0001
Complications	0 (0.0)	113 (5.3)	
Surgical approach			
Laparoscopic procedure	24,357 (99.5)	3274 (96.8)	< 0.0001
Open procedure	61 (0.25)	79 (2.3)	
Laparoscopic conversion to open	59 (0.25)	30 (0.9)	
Length of hospital stay (days)	2.7 ± 2.7	3.2 ± 5.2	< 0.0001

SD standard deviation, *BPD* biliopancreatic diversion

weight loss or weight gain, and 11% are associated with both [14]. Our series showed that most RSs were performed for inadequate weight loss or weight gain and few were performed for complications. This reflects the fact that most patients undergoing RS had previously undergone vertical banded gastroplasty (VBG) or gastric banding, similar to the findings reported by Fulton et al. [16]. This is not surprising as studies have shown that up to 56% of VBG patients would need RS over a period of 12 years, mainly because of failure to maintain adequate weight loss, pouch and stoma dilation/stenosis, vomiting, band erosion, and severe gastroesophageal reflux disease [20–22]. The use of laparoscopic adjustable gastric banding (LAGB) has significantly decreased owing to its high failure rate and complications, with over 50% of patients requiring RS [23]. The band complication rate has been estimated to be 4.7% per year [24]. We performed a cross analysis with the national hospitalization registry and the bariatric registry. From the 113 revisional patients due to complications, 69 (61%) were hospitalized between the primary and revisional surgeries. Among these patients, 15 (13.2%) were due to reflux disease, being the most frequent reason for this additional hospitalization. We can estimate that GERD was an important factor for revisional surgery.

The distribution of the types of surgeries was very different between the PS and RS groups. Most PSs involved SG, whereas most RSs involved bypass, and these findings are consistent with the results in a previous report [4].

Consistent with the findings in other studies, we noted a significantly longer duration of hospitalization and a higher rate of conversion to open surgery in the RS group than in the PS group [25–28]. Another report mentioned a hospitalization duration of 3 days for RS [29].

The total complication rates were 6.2% and 3.5% in the RS and PS groups, respectively, and these findings are similar to the results in previous studies [30–32]. However, the rate in the RS group is relatively low when compared with a rate of up to 50% reported in other series [7, 33]. Leakages or abscesses are the primary causes of morbidity in BS and are more common in RS [34]. In the present study, the rate of leakage or abscess was significantly higher in the RS group. Other series found similar and higher leakage rates in RS (2.1–4%) [25, 35, 36].

At the 1-year follow-up, the %EWL was significantly different between the PS and RS groups. The standardization of weight loss following revision is difficult, with much variation, and it depends primarily on patient characteristics and the surgery performed [17, 37, 38]. Studies have shown that weight loss is the highest at 1 year and that weight gain from this point is noted after PS [39, 40]. Similar results with significantly lower %EWL were observed in revision laparoscopic RYGB after 1–2 years [12, 41]. A previous study has reported that when RYGB is performed after band failure to restore weight loss or after the development of a complication, the weight loss curve is similar to that after primary RYGB [31]. Less weight loss after revision RYGB has been reported following primary laparoscopic SG [42].

Among band patients, revision banding was performed in only 18.7% of cases, and most of the patients underwent revision SG or bypass. Revision banding is not effective in terms of long-term weight loss and is associated with high morbidity [43, 44]. Our series showed similar proportions between revision bypass (41.1%) and SG (40.2%) after primary banding. Bypass after failed banding has been reported to show acceptable long-term weight loss, low surgical

Table 3 Postsurgical outcomes of bariatric surgery during hospitalization in the primary and revision surgery groups

	Primary surgery *N* = 28,707 *N* (%) or mean ± SD	Revision surgery *N* = 4026 *N* (%) or mean ± SD	*P* value
% TWL	25.1 ± 8.1***	18.5 ± 8.9***	*< 0.0001*
(6 months postoperatively)	*N* = 18,475	*N* = 2132	
% TWL	30.5 ± 9.5***	23.2 ± 11.4***	*< 0.0001*
(1 year postoperatively)	*N* = 14,025	*N* = 1596	
BMI units lost	10.6 ± 3.8***	8.1 ± 4.3***	*< 0.0001*
(6 months postoperatively)	*N* = 18,466	*N* = 2129	
BMI units lost	12.9 ± 4.6***	10.1 ± 5.4***	*< 0.0001*
(1 year postoperatively)	*N* = 14,020	*N* = 1594	
%EWL	64.3 ± 22.4**	49.3.3 ± 34.7**	*< 0.001*
(6 months postoperatively)	*N* = 18,464	*N* = 2125	
%EWL	77.9 ± 25.2***	60.7 ± 36.7***	*< 0.0001*
(1 year postoperatively)	*N* = 14,013	*N* = 1591	
Blood tests			
Vitamin B12 (≤ 211 pg/ml)			
Pre-surgery	2367 (10.6)	300 (10.0)	*0.3*
	N = 22,344	*N* = 3001	
6 months after surgery	1511 (9.9)*	209 (11.9)*	*0.008*
	N = 15,248	*N* = 1753	
1 year after surgery	1497 (13.7)	183 (14.5)	*0.5*
	N = 10,887	*N* = 1266	
Ferritin (≤10 ng/ml)			
Pre-surgery	2563 (13.4)***	465 (18.0)***	*< 0.0001*
	N = 19,098	*N* = 2577	
6 months after surgery	523 (4.1)***	120 (8.3)***	*< 0.0001*
	N = 12,855	*N* = 1443	
1 year after surgery	618 (7.0)***	137 (13.3)***	*< 0.0001*
	N = 8870	*N* = 1032	
Hemoglobin (≤8 g/dl)			
Pre-surgery	2740 (11.0)***	538 (16.2)***	*< 0.0001*
	N = 25,016	*N* = 3318	
6 months after surgery	2874 (15.5)***	543 (24.2)***	*< 0.0001*
	N = 18,499	*N* = 2237	
1 year after surgery	2823 (19.5)***	471 (26.1)***	*< 0.0001*
	N = 14,515	*N* = 1803	
	N = 24,531	*N* = 3389	
Total complications (%)	856 (3.5)***	210 (6.2)***	*< 0.0001*
Bleeding	541 (2.2)	84 (2.5)	0.3184
Sepsis	10 (0.04)**	7 (0.2)**	*0.0002*
Surgical-site infection	59 (0.2)***	32 (0.9)***	*< 0.0001*
Leakage or abscess	118 (0.5)***	68 (2.0)***	*< 0.0001*
Venous thromboembolism	18 (0.07)*	8 (0.2)*	*0.004*
Cardiorespiratory	154 (0.6)***	47 (1.4)***	*< 0.0001*
Death	108 (0.4)***	20 (2.0)***	*< 0.0001*
	N = 28,707	*N* = 4026	

complications, and comorbidity improvement [45, 46]. This is despite long-term nutritional issues and hypoglycemia that can be successfully treated [47]. A previous study comparing band revision and bypass or SG has shown that both approaches are feasible and effective, with satisfactory weight loss [48, 49].

In our series, most primary SG patients underwent revision bypass (88.6%) and few underwent revision SG, particularly when the issue was associated with sleeve dilation or a retained fundus. Studies have reported high complication rates after revision SG [50, 51]. There was a low frequency of banded SG. This is emphasized in other studies on how to

Table 4 Bariatric surgeries in patients undergoing revision surgery according to the primary surgery

	Type of revision surgery				
	Gastric banding (LAGB)	Sleeve gastrectomy	Roux-en-Y gastric bypass/omega loop mini	Others[2]	*P* value
Type of primary surgery					
Gastric banding (LAGB) and vertical banded gastroplasty (*N* = 3272)	613 (18.7)	1314 (40.2)	1238 (37.8)	107 (3.3)	0.0001
Sleeve gastrectomy (*N* = 536)	25 (4.7)	36 (6.7)	448 (83.6)	27 (5.0)	
Roux-en-Y gastric bypass/omega loop mini (*N* = 53)	14 (26.4)	15 (28.3)	21 (39.6)	3 (5.7)	
Others[1] (*N* = 1)	1 (100.0)	0	0	0	
Unknown (*N* = 164)	28 (17.1)	114 (70.0)	21 (12.8)	1 (0.6)	

Duodenal switch (BPD-DS), Scopinaro procedure (BPD), vertical banded gastroplasty, one anastomosis duodenal switch (omega loop)

N = 4026

BPD biliopancreatic diversion

[1] The "others category" in primary surgery includes one duodenal switch (BPD-DS) and one unknown surgery

[2] The "others category" in revision surgery includes 95 Scopinaro procedures (BPD), 24 one anastomosis duodenal switch (omega loop) procedures, and 18 duodenal switch (BPD-DS) procedures

proceed with failed sleeves, and banding has not been mentioned as an option [52]. In contrast, a recent report on banding for gastric sleeve dilation showed feasible results, and the approach was found to be safe and effective for maintaining weight loss, with a low incidence of band-related problems [53]. According to the SG summit, RS selection is based on surgeon preference and not necessarily on agreed guidelines. Most surgeons prefer revision bypass and not additional restrictive surgery [54].

Table 5 Multivariate linear regression model for factors associated with excess weight loss 1 year after revision surgery among patients who had undergone primary surgery involving gastric banding or sleeve gastrectomy, according to the revision surgery type (*N* = 1148)

Parameter	*β*	*P* value
Age*	−0.44	*< 0.001*
Sex (male)	−3.40	0.093
Population group (Jews vs. Arabs)	3.82	0.160
Marital status (married)	0.73	0.685
Current smoking*	8.55	*< 0.001*
BMI before BS*	−0.78	*< 0.001*
No. of comorbidities (0–1, 2–3, > 3)	0.35	0.785
Type of revision BS Roux-en-Y gastric bypass/omega loop mini/duodenal switch/omega loop/BPD after restrictive BS (gastric banding or sleeve gastrectomy) vs. banding or sleeve gastrectomy after restrictive BS (gastric banding or sleeve gastrectomy)**	4.17	*0.018*

BMI body mass index, *BS* bariatric surgery, *BPD* biliopancreatic diversion; * Significant at the 0.001 probability level; ** Significant at the 0.01 probability level

A literature review including 11 primary studies with 218 patients after SG did not find a significant difference in efficacy at the 24-month follow-up between revision bypass and revision SG [40]. However, another study found that it is preferable to perform bypass surgery after failed SG. Dapri et al. compared revision SG and duodenal switch and reported greater %EWL in the duodenal switch group than in the SG group [51].

Despite the success of RYGB, up to 20% of patients undergoing RYGB show weight regain or inadequate weight loss [11, 55]. Our series showed that primary gastric bypass was mainly associated with revision involving another type of bypass. The type of RS is selected according to the issue leading to RS. Inadequate weight loss was treated by changing the bypass anatomy (dilated stoma or gastrogastric fistula) or performing revision long-limb RYGB. Few patients underwent SG or banding. Additional revision bypass is a good option for weight loss, but it might involve nutritional complications that can be treated successfully with close follow-up [4, 56, 57]. Inadequate patient adherence and compliance to nutritional supplementation and regular follow-up visits are reported in the literature [15, 58]. In these bypass to bypass patients, it poses a major factor on their long-term health. Our study reported 14 cases of revision banding after primary bypass. Revision banding after gastric bypass has been shown to be associated with a high complication rate and morbidity [59]. On the other hand, a recent large series showed that LAGB after prior RYGB is safe, with a reduction in the surgical risks and nutritional deficiencies often seen with other accepted RSs. Additionally, the complication rates were the same as those for primary LAGB, with predictable weight loss and feasibility [60–62]. There were 15 conversions from bypass to SG. This type of revision is rare and is undertaken for refractory complications, such as marginal

ulceration, stricture, dumping, gastrogastric fistula, hypoglycemia, and failed weight loss, which are associated with high complication rates [63, 64].

The multivariate model showed that old age, male sex, and high BMI before BS were associated with low %EWL after primary restrictive surgery. Old age is known to be associated with decreased weight loss after BS, and this might be related to an age-related decline in the metabolic rate [65]. The results of studies on sex and outcomes are inconsistent [66–68]. On the other hand, population group (Jews vs. Arabs), current smoking, and RS type (bypass vs. additional restrictive surgery) were associated with high %EWL. Other BS studies have not found any correlation between %EWL and smoking [69].

The options for RS should be tailored according to PS and should be evaluated by a multidisciplinary team [70]. Considering that the primary indications for most RSs are weight regain and inadequate weight loss, when PS is restrictive (banding or SG), RS should be some type of bypass, as shown by the multivariate regression model.

The present study had several limitations. First, the data review and analysis were retrospective. Second, the follow-up period was only 1 year. Nevertheless, this study included a very large cohort.

In conclusion, the RS rate is continuously increasing with the increasing rates of obesity and BS, and it should be tapered according to indications and feasibility. Our findings indicate that RS can be performed with acceptable complication rates and that restrictive surgery should be converted to bypass surgery to achieve acceptable weight loss with fewer complications.

Compliance with Ethical Standards

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

For this type of study, formal consent is not required.

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

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