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ORIGINAL CONTRIBUTIONS

Midterm Outcome of Laparoscopic Sleeve Gastrectomy in Asians: a Systematic Review and Meta-analysis

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Abstract

Background Laparoscopic sleeve gastrectomy (LSG) is a commonly performed bariatric surgery. Studies have suggested that LSG can provide effective and sustainable weight loss although most of them were conducted in Western populations. Our aim was to characterize the midterm outcome of LSG in Asians with obesity.

Methods MEDLINE and EMBASE were searched through August 2019 for studies that reported % total body weight loss (TBWL) and/or % excess weight loss (EWL) at 3 and/or 5 years among adult Asians with obesity who underwent LSG. Data on complications and surgical revision rate were also extracted. The pooled effect size and 95% confidence interval (CI) were calculated using a random effects model.

Results A total of 19 studies involving 6235 patients were included. The pooled mean %EWLs were 72.6% (95% CI 67.2–78.0, $I^2 = 97\%$); 67.1% (95% CI 61.7–72.6, $I^2 = 95\%$); and 59.1% (95% CI 48.8–69.4, $I^2 = 94\%$) at 1, 3, and 5 years, respectively. The pooled mean %TBWLs were 32.1%, 29.0%, and 25.5% at 1, 3, and 5 years, respectively. The pooled rates of revision due to gastroesophageal reflux disease and weight regain were 1.9% and 2.5%, respectively.

Conclusions Our meta-analysis suggests that LSG is an effective procedure for weight reduction that offers durable response for up to 5 years among Asians with obesity. The longer-term data is needed.

Keywords Asians · Meta-analysis · Obesity · Sleeve gastrectomy · Surgical revision · Weight regain

Introduction

Bariatric surgery is the most effective intervention to provide substantial and durable weight loss [1]. Laparoscopic sleeve gastrectomy (LSG) is the most commonly performed bariatric surgery in the USA, accounted for over 50% of all cases [2]. Compared with Roux-en-Y gastric bypass (RYGB), long-term outcomes of LSG are relatively less well described, especially in non-Western populations as it is a relatively newer procedure. An increasing number of studies have suggested

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Table 1 Characteristics of the included studies

Author/ year	Country	Study design	Study period	Recruitment of subjects	Number of subjects at baseline, 3 and 5 years	Female (%)	Age ± SD (years)	Initial BMI ± SD (kg/ m^2)	No. of patients with DM (%)	Rate of loss to follow-up 3 years	Rate of loss to follow-up 5 years	Follow-up duration (years)
Chang et al. 2018	Taiwan	RC	2005–2017	Patients underwent LSG at Min-Sheng General Hospital were included.	1450/NA/354	69.7	35.2 ± 10.3	37.9 ± 7.7	20.7	NA	75.6	10
Toh et al. 2018	Singapore	RC	2010–2016	Patients underwent LSG at Singapore General Hospital were included.	393/53/15	61.8	40 ± 11	43.0 ± 7.9	18.6	86.5	96.2	5
Park et al. 2017	South Korea	RC	2013–2016	Patients underwent LSG at Gil Medical Center, Gachon University, South Korea, were included.	74/39/NA	78.4	30.4 ± 7.9	34.7 ± 53.6	14.9	47.3	NA	3
Kim et al. 2018	Singapore	RC	2008–2015	Patients underwent LSG at National University, Singapore, were included.	256/71/NA	58.2	39.5 ± 11.2	43.0 ± 7.6	NA	72.3	NA	3
Hans et al. 2017	China	RC	2011–2016	Patients underwent LSG by a single surgeon at Nanjing Medical University, China, were included.	218/30/2	68.8	29.9 ± 7.3	38.3 ± 6.2	17.0	86.2	99.1	5
Garg et al. 2017	India	RC	2008–2015	Patients underwent LSG at All India Institute of Medical Sciences were included.	424/171/52	66.7	39.8 ± 11.2	46.7 ± 7.9	28.5	60.0	87.7	7
Du et al. 2016	China	RC	2009–2013	Patients underwent LSG at West China Hospital, China, were included with 1:1 matched to the laparoscopic Roux-en-Y gastric bypass.	63/62/NA	66.7	34.6 ± 10.4	38.9 ± 5.4	25.4	1.6	NA	3
Wang et al. 2016	China	RC	2011–2012	Patients underwent LSG at Changhai Hospital of the Second Military Medical University, China, were included.	70/41/NA	57.1	30.3 ± 8.6	40.8 ± 5.9	41.4	41.4	NA	3
Seki et al. 2015	Japan	RC	2005–2013	Patients underwent LSG at Yotsuya Medical Cube, Japan, were included.	179/32/19	49.7	40.7 ± 11.2	43.3 ± 10.0	NA	82.1	89.4	5
Pok et al. 2015	Malaysia	RC	2006–2012	Patients underwent LSG who have completed at least 6 months of follow-up were included.	669/66/61	74.7	34.5 ± 9.7	37.5 ± 1.4	NA	90.1	90.9	5
Liu et al. 2015	Hong Kong	PC	2006–2014	Patients underwent LSG at Prince of Wales Hospital, Hong Kong, were included.	140/89/52	65	37.9 ± 10.5	41.0 ± 7.0	46.4	36.4	62.9	5
Yang et al. 2015	China	RT	2009–2014	Patients with BMI of 28–35 kg/m^2 in the 1st Affiliated Hospital and Jihua Hospital of Jinan University, Guangzhou, China, were included.	32/28/NA	71.9	40.4 ± 9.4	31.8 ± 3.0	100	12.5	NA	3
Park et al. 2014	South Korea	RC	2009–2012	Patients underwent LSG at Soonchunhyang University, Seoul Hospital, Korea, were included.	192/108/NA	68.2	33.1 ± 9.6	40.0 ± 7.2	21.4	43.8	NA	4
Zhang et al. 2014	China	RT	2007–2008	Patients underwent LSG at Nankai Hospital, China, were included.	32/30/26	62.5	29.3 ± 9.8	38.5 ± 4.2	28.1	6.3	18.8	5
Kular et al. 2014	India	RC	2007–2013	Patients underwent LSG at Kular Hospital, India, were included.	118/NA/76	NA	NA	42 ± 5.2	51.7	NA	35.6	5
Hong et al.	South Korea	RC	2003–2013	Patients underwent LSG at Gangnam CHA Medical Center, South Korea, were included.	75/54/32	94.4	33.7 ± 10.3	32.4 ± 1.6	14.7	28.0	57.3	5

Table 1 (continued)

Author/year	Country	Study design	Study period	Recruitment of subjects	Number of subjects at baseline, 3 and 5 years	Female (%)	Age ± SD (years)	Initial BMI ± SD (kg/m^2)	No. of patients with DM (%)	Rate of loss to follow-up 3 years	Rate of loss to follow-up 5 years	Follow-up duration (years)
2014												
Sharma et al. 2014	India	RT	NA	Patients underwent LSG at Asian Bariatric and Cosmetics, India.	15/14/NA	40.0	39.9	44.0 ± 7.8	53.3	6.7	NA	3
Zachariah et al. 2013	Taiwan	RC	2007–2012	Patients underwent LSG at E-Da Hospital, Taiwan, were included.	228/33/6	63.6	34.7 ± 10.1	37.4 ± 4.8	13.2	85.5	97.4	5
Prasad et al. 2012	India	PC	2008–2011	Patients underwent LSG by a single surgical team at ILS Hospital, India, were included.	110/21/NA	76.4	39.3 ± 11.2	44.6 ± 6.8	42.7	80.1	NA	3

NA not available, *PC* prospective cohort, *RC* retrospective cohort, *RT* randomized trial, *LSG* laparoscopic sleeve gastrectomy

that LSG can provide effective and sustainable weight loss with the average of about 50% excess weight loss (%EWL) at 5 years after surgery, similar to the average of about 60% EWL at 5 years after RYGB [3]. The surgical revision rate was 13% due to weight regain and 3% due to gastroesophageal reflux disease (GERD) at 7 years or more after LSG [4]. However, these data are predominantly from the Western countries that may not be generalizable to other populations. Some studies have shown racial disparities in the outcomes of bariatric surgery, in which LSG may be less effective among Asians [5–7]. Moreover, the obesity phenotype of Asians may be different from that of Caucasians as Asians tend to have higher body fat and visceral fat compared with Caucasians despite lower body weight [8–10], resulting in a higher risk of type 2 diabetes and metabolic syndrome.

The current meta-analysis aimed to comprehensively identify all available studies that reported midterm outcomes (up to 5 years) of LSG in Asian populations to better characterize the efficacy and complications of LSG among these populations.

Materials and Methods

Search Strategy

Two authors (PU and VJ) independently searched for published articles indexed in Ovid/MEDLINE and EMBASE databases from inception to August 2019 using the search term of "sleeve gastrectomy." No language restriction was applied. Reviews, case reports, and letters were excluded. References of selected retrieved articles were also manually reviewed for additional potentially relevant studies.

Eligibility Criteria

Eligible observational studies or randomized controlled trials must meet all of the following inclusion criteria: (1) participants were adults (age of more than or equal to 18 years old) with obesity who underwent LSG; (2) the follow-up duration was at least 3 years; (3) % total body weight loss (TBWL) and/or %EWL at 3 and/or 5 years were reported; and (4) the study was conducted in an Asian country. Two authors (PU and VJ) independently reviewed the eligibility of the retrieved articles. Disagreements were identified and discussed with all authors. If there were more than one eligible study that reported data from the same group of patients, only one study with most comprehensive information was selected for inclusion.

Data Extraction

The following data were independently extracted by the same 2 authors using a standardized study record form: first author name; country where the study was

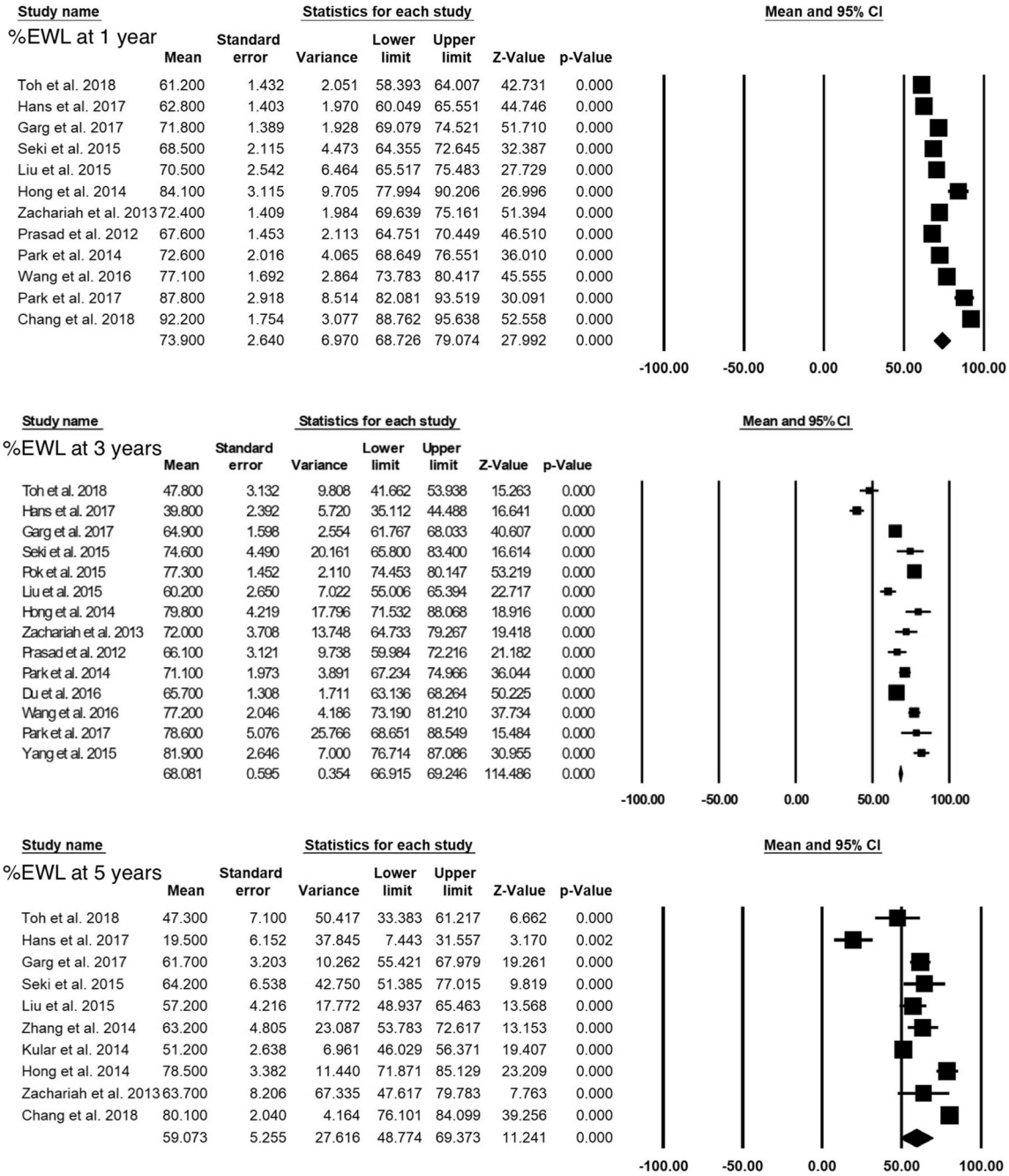

Fig. 1 Forest plots of % excess weight loss at 1 year, 3 years, and 5 years after LSG

conducted; year of publication; study design; baseline characteristics of the patients; number of the patients at follow-up; %TBWL and %EWL at 1, 3, and 5 years; surgical revision rate; and complications. For randomized controlled trials, data were extracted only from LSG arm (i.e., data from non-LSG participants were not used). The corresponding authors of the included articles were contacted if additional data were required for the meta-analyses.

Statistical Analysis

The %TBWL and %EWL at 1, 3, and 5 years after LSG, complication, and surgical revision rate were extracted from each study. The pooled effect size and 95% confidence interval (CI) were calculated using a random effects model. The heterogeneity of effect size estimates across the studies was quantified using the Q statistic and I^2 ($P < 0.10$ was considered significant). An I^2 value of 0–25% indicates insignificant heterogeneity, 26–50% indicates

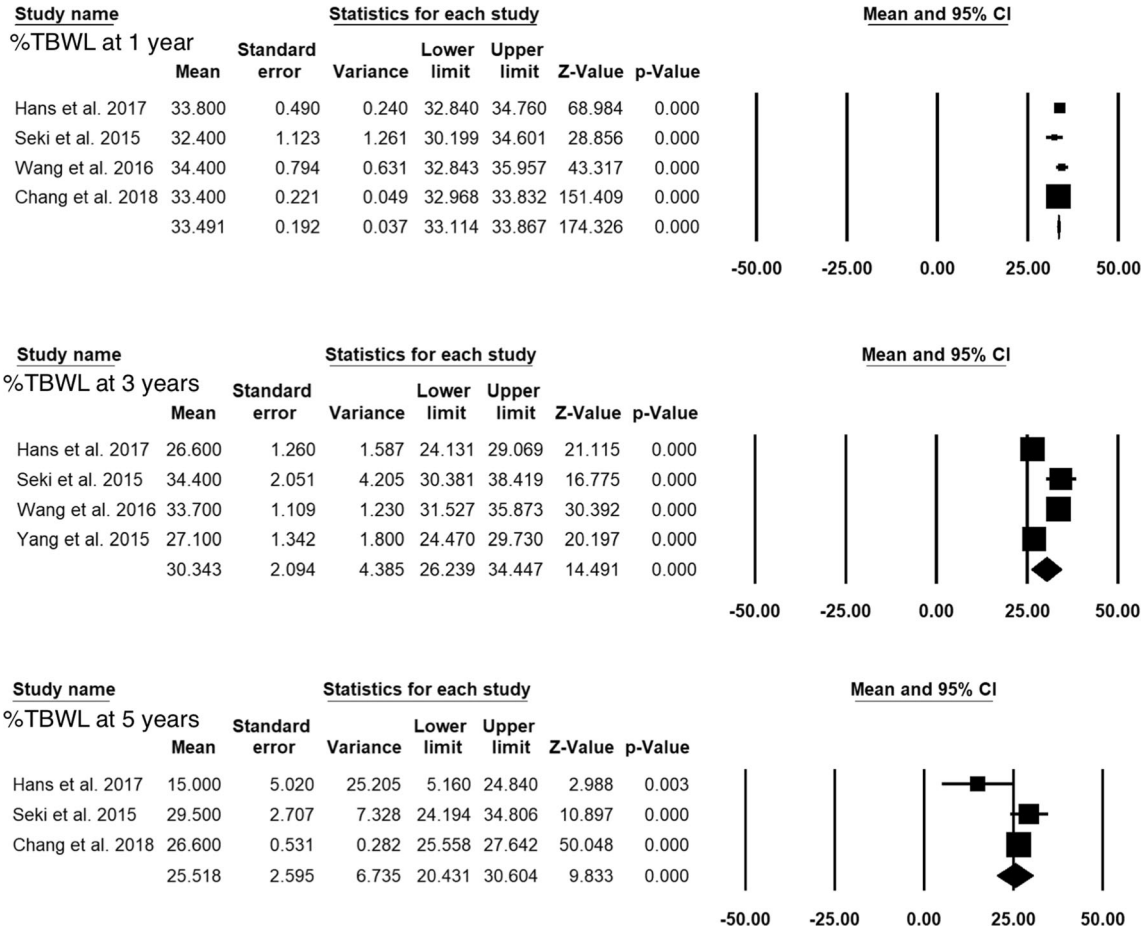

Fig. 2 Forest plots of % total body weight loss at 1 year, 3 years, and 5 years after LSG

low heterogeneity, 51–75% indicates moderate heterogeneity, and 76–100% indicates high heterogeneity [11]. Publication bias was assessed using funnel plots. All analyses were performed using the Comprehensive Meta-Analysis program, version 2.2 (Biostat, Englewood, NJ, USA).

Results

The initial search yielded 16,704 potentially relevant articles (13,222 articles from EMBASE and 3,482 articles from MEDLINE). After the exclusion of 2,175 duplicated articles, 14,529 articles underwent title and abstract review. A total of 14,482 articles were excluded at this stage, as they clearly did not fulfill the eligibility criteria, leaving 47 articles for full-length review. Thirty articles were excluded after a full-length review with reasons shown in Supplementary File 1. Finally, 19 studies [12–28] involving 6,235 Asian patients with obesity who underwent LSG met the eligibility criteria and were included into the meta-analyses. The detailed characteristics of the included studies are described in Table 1. In brief, most studies had more women (% female 40.0–94.4) patients than men. The sample sizes ranged from 15 to 1,759 patients. The mean age ranged from 29.3 to 40.7 years. The mean baseline body mass index ranged from 31.8 to 46.7 kg/m^2.

Weight Reduction After Laparoscopic Sleeve Gastrectomy

For %EWL, 14 [13, 15–18, 20–22, 24–26, 28–30], 16 [13–22, 24–27, 29, 30], and 10 [12, 13, 16, 17, 22–26, 28] studies involving 4027, 1317, and 911 patients reported %EWL at 1, 3, and 5 years, respectively. The pooled mean %EWLs were 72.6% (95% CI 67.2–78.0, $I^2 = 97\%$); 67.1% (95% CI 61.7–72.6, $I^2 = 95\%$); and 59.1% (95% CI 48.8–69.4, $I^2 = 94\%$) at 1, 3, and 5 years, respectively (Fig. 1).

For %TBWL, 5 [15, 17, 25, 28, 29], 5 [14, 15, 17, 25, 29], and 3 [17, 25, 28] studies (reviewer 1) involving 1922, 202, and 375 patients reported %TBWL at 1, 3, and 5 years, respectively. The pooled mean %TBWLs were 32.1% (95% CI 30.0–34.2, $I^2 = 94\%$); 29.0% (95% CI 25.0–33.1, $I^2 = 91\%$); and 25.5% (95% CI 20.4–30.6, $I^2 = 69\%$) at 1, 3, and 5 years, respectively (Fig. 2).

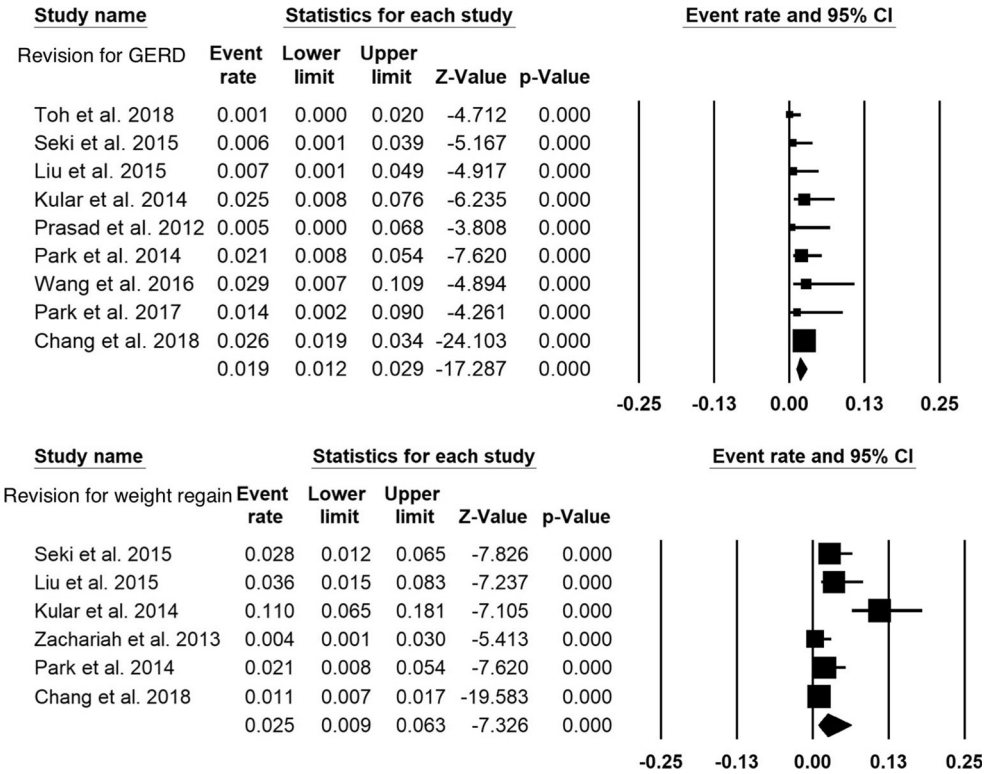

Fig. 3 Forest plots of surgical revision rate due to gastroesophageal reflux disease and weight regain

Revisional Surgery After Laparoscopic Sleeve Gastrectomy

A total of 9 and 6 studies reported the rate of surgical revision because of GERD and weight regain, respectively. The pooled rates of revision due to GERD and weight regain were 1.9% (95% CI 1.2–2.9%, $I^2 = 20\%$) and 2.5% (95% CI 0.9–6.3%, $I^2 = 89\%$), respectively (Fig. 3).

Post-operative Complications

Fifteen studies reported the complications in detail [12–15, 17–27]. From 2,676 patients, 150 early post-operative complications (5.6%) occurred (most studies defined early complications as within 30 days after surgery). The most common early complications were bleeding (43 patients, 1.6%, ranging from 0 to 5.6%), followed by leaks (34 patients, 1.3%, ranging from 0 to 2.8%), wound infection (31 patients, 1.2%, ranging from 0 to 6.4%), and wound dehiscence (21 patients, 0.8%, ranging from 0 to 10%). Uncommon complications included gastric stenosis (5 patients), atelectasis (4 patients), bowel injury (2 patients), deep vein thrombosis (2 patients), port site hernia (2 patients), abdominal wall abscess (2 patients), perforation (1 patient), and splenic injury (1 patient). Out of 150 early complications, 48 patients required interventions for their complications. Late complications included GERD (43 patients), stricture (1 patient), and esophageal dysmotility (1 patient). There were 2 deaths after LSG (0.07%); one was from pneumonia and the other one was due to respiratory failure from undiagnosed obstructive sleep apnea.

Publication Bias

Funnel plots were created from the 3 analyses with the highest number of studies including %EWL at 1 year, 3 years, and 5 years to evaluate for the presence of publication bias. All 3 funnel plots were relatively symmetric and were not suggestive of presence of publication bias (Fig. 4).

Discussion

LSG is an effective and durable bariatric surgery that has gained worldwide popularity, including Asia. However, it is a relatively newer procedure compared with RYGB that has recently been endorsed as a stand-alone primary bariatric surgery by the American Society Bariatric and Metabolic Surgery (ASMBS) in 2012 [31]. In addition, its largest body of evidence comes from Western populations that its efficacy and complications in Asians with obesity are still not well described.

The current study took the advantage of a systematic review and meta-analysis technique to summarize data from all available studies. We found that the mean EWL at 1, 3, and 5 years after surgery surpass the minimal cutoff of 50% EWL recommended by the ASMBS to be considered a successful weight loss tool

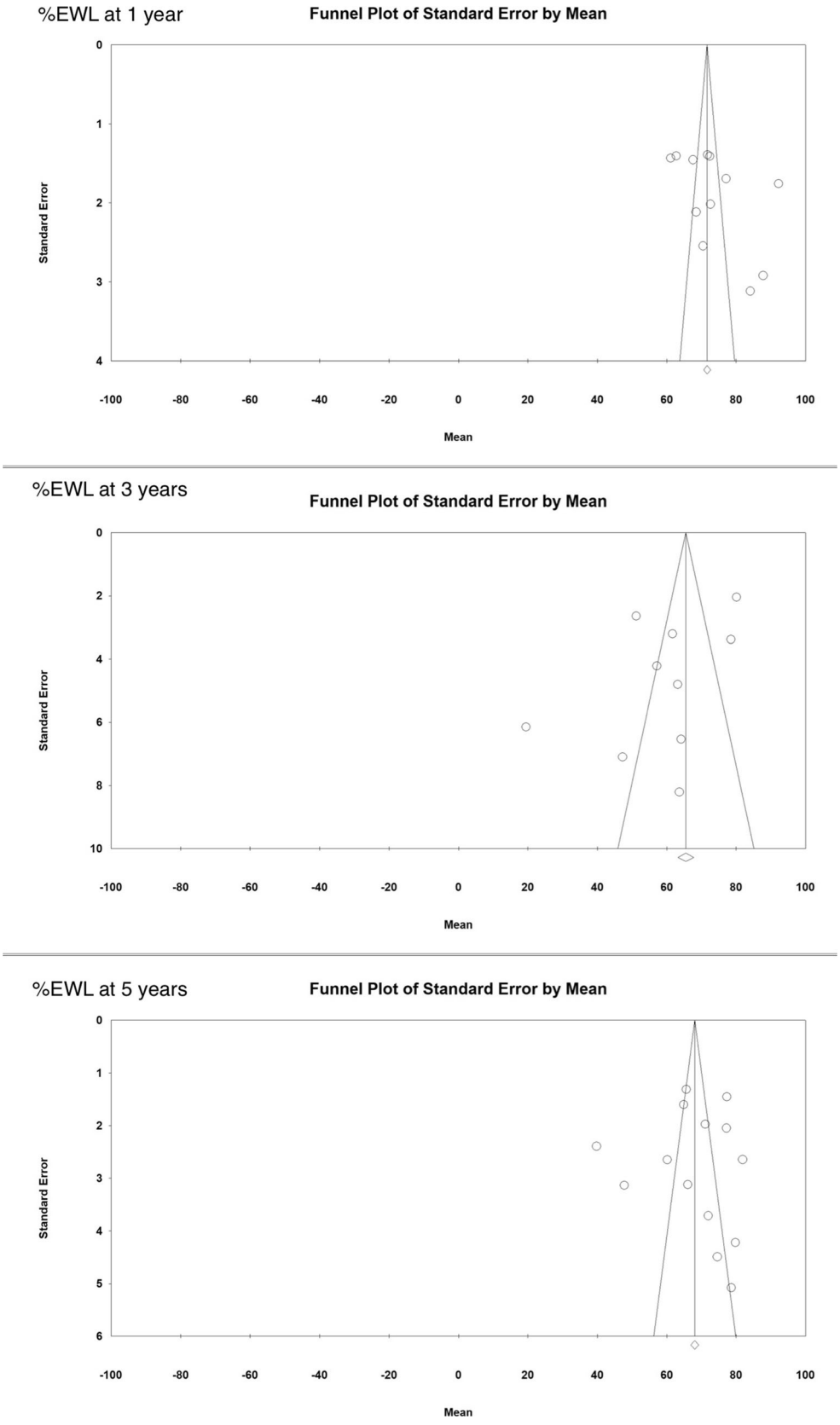

Fig. 4 Funnel plots of % excess weight loss at 1 year, 3 years, and 5 years after LSG

and the efficacy is sustainable for up to 5 years. Interestingly, the current study observed the maximal weight loss at 1 year with a slight decline in weight reduction at 3 years, which is different from observations of the previous systematic review that

included studies from every region around the world that found the maximal weight loss at 3 years after LSG [32].

The need for surgical revision is a major concern of patients who undergo LSG. The two most common indications are weight regain/insufficient weight loss and GERD. Our meta-analysis including studies with a follow-up duration of more than 3 years found a pooled surgical revision rate for weight regain of only 2.5%, which is lower than the pooled revision rate of 13.1% reported by a meta-analysis that included data from all regions of the world. Nonetheless, it should be noted that the previous meta-analysis included studies of a longer follow-up period (7 years or more) [4]. De novo or worsening GERD is another drawback of LSG as a result of high intragastric pressure associated with the sleeved stomach and the possible disruption of the lower esophageal sphincter from the transection of the sling fibers [33, 34]. A multicenter study involving 90 patients demonstrated a high prevalence of Barrett's esophagus of almost 20% after 5 years of LSG [35]. The current study found a pooled revision rate for GERD of 1.9% among Asian patients compared with the pooled revision rate of 2.9% for GERD from the previous global meta-analysis [4]. It should be noted that the diagnostic criteria for GERD have not been well described in our included studies.

Despite the advantage of the systematic review and meta-analysis technique that comprehensively summarizes all available data, the current study has some limitations that may affect the validity of our pooled results. First, this current study is a meta-analysis of descriptive studies that is generally considered of lower quality and most of the included studies were retrospective studies, in which the reported data could be incomplete and/or inaccurate. Second, the primary studies included in this meta-analysis had a high loss to follow-up rate. Therefore, the results could be skewed if patients who failed to show up were significantly different from the analyzed patients. Some of the included studies tried to increase the follow-up rate by reaching out to patients who did not return for follow-up visit using telephone interview. However, information gathered by this approach could be less reliable. Third, high between-study heterogeneity was observed, which could be a result of different study protocols and patient populations.

In conclusion, the current meta-analysis suggested that LSG is an effective procedure for weight reduction that offers durable response for up to 5 years among Asians with obesity. In addition, the observed surgical revision rate appears to be lower than previously reported data from other populations. Further studies of long-term efficacy of this procedure (> 5 years) are warranted.

Author Contributions Jaruvongvanich, Veeravich, MD, conceived the study, searched the literature, extracted the data, assessed the quality of the studies, and drafted the manuscript. Ungprasert, Patompong, MD, MS, searched the literature, extracted the data, assessed the quality of the studies, performed the statistical analysis, and drafted the manuscript. Vantasiri, Kornpong, MD; Wongjarupong, Nicha, MD; and Samakkarnthai, Parinya, MD, extracted the data, assessed the quality of the studies, and drafted the manuscript. All authors read and approved the final manuscript.

Compliance with Ethical Standards

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

Ethical Approval This article does not contain any studies with human participants or animals performed by any of the authors.

Informed Consent No informed consent.

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