Single Incision Versus Conventional Laparoscopic Sleeve Gastrectomy for Morbid Obesity: A Meta-Analysis

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Abstract

Introduction: The purpose of this study was to review the existing evidence on obese patients treated with single-incision laparoscopic sleeve gastrectomy (SILSG) or conventional laparoscopic sleeve gastrectomy (LSG), to compare the perioperative parameters and outcomes of the two bariatric procedures.

Materials and Methods: A systematic literature search was performed in PubMed, Scopus, and Cochrane library, in accordance with the PRISMA guidelines. Seventeen articles met the inclusion criteria and incorporated 3843 patients.

Results: This study reveals comparable mean operative time, length of hospital stay, and complications between the two approaches. The SILSG approach was associated with enhanced cosmetic results, but increased incisional hernia rate.

Conclusions: These outcomes should be treated with caution given the small number of included comparative studies. Well-designed, randomized controlled studies, comparing LSG to SILSG, are necessary to assess further their clinical outcomes.

Keywords: SILSG, LSG, single-incision sleeve gastrectomy, laparoscopic sleeve gastrectomy, sleeve gastrectomy, obesity

Introduction

Obesity is a rising epidemic in Western societies, while bariatric surgery continues to be a major therapeutic mode for a high rate of sustainable weight loss, along with glycemic control. A bariatric procedure that currently has gained increased popularity is laparoscopic sleeve gastrectomy (LSG). In fact, LSG was the most frequently performed bariatric procedure globally in 2014. Nonetheless, based on the success of single-incision technique for numerous urologic and gynecologic procedures, a laparoscopic single-incision approach was also implemented in sleeve gastrectomy.

Single-incision laparoscopic technique has been implemented in several surgical procedures. Single-incision laparoscopic sleeve gastrectomy (SILSG) was first reported in 2008 as an alternative approach to conventional LSG. SILSG has been associated with certain potential advantages, such as improved cosmesis, lower postoperative pain, and fewer wound complications. As the number of studies assessing the feasibility of SILSG increases, it is necessary to examine whether the results between the two techniques are at least equivalent. The purpose of this study is to summarize the existing evidence comparing the surgical outcomes of LSG and SILSG in the treatment of morbid obesity.

Materials and Methods

Search strategy and article selection

This study was conducted in accordance with a protocol agreed by all participating authors and the Preferred Reporting Items for Systematic Reviews and Meta-Analyses. A thorough literature search was performed in PubMed (Medline), Scopus (ELSEVIER), and Cochrane Central Register.

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of Controlled Studies (CENTRAL) databases (last search: February 20, 2017) using the following terms in every possible combination: “single-incision,” “single-port,” “single-access,” “transumbilical,” “conventional,” “multiport,” “laparoscopic,” and “sleeve gastrectomy.” The inclusion criteria of this study were (1) original articles with ≥10 patients, (2) written in English language, (3) published from 1980 to 2017, (4) conducted on human subjects, and (5) reporting outcomes of either LSG or SILSG on morbidly obese patients. Two independent investigators (D.E.M. and V.S.T.) extracted data from the included studies. Any discrepancies between the two reviewers about the inclusion or exclusion of studies were discussed with the senior author (D.Z.) to include articles that best matched the protocol, until consensus was reached. In addition, the reference lists of all articles, which were finally included, were further assessed for possibly eligible articles.

Data extraction

For each study that was included, data were extracted relative to demographics (sample size for each group, age, sex, preoperative body mass index [BMI], and comorbidities) along with the perioperative outcomes (single-port devices used, mean operative time, mean hospital stay, bougie diameter, conversion rate, doses of analgesics, and intraoperative and postoperative complications). Two investigators (D.E.M. and V.S.T.) performed the data extraction and compared the validity of the data until consensus was reached.

Statistical analysis

Regarding the categorical outcomes, the odds ratio (OR) and 95% confidence interval (95% CI) were evaluated, by means of random-effects model (Mantel-Haenszel statistical method). OR >1 denoted outcome was more frequent in the SILSG group. Continuous outcomes were calculated by means of weighted mean difference (WMD) with its 95% CI, using random-effects (inverse variance statistical method) models. In cases where WMD <0, values in the SILSG group were increased. The random-effects model was chosen because we did not expect that the all the included studies would share a common effect size. Between-study heterogeneity was assessed through Cochran Q statistic and by estimating I². Data analysis was performed using the Cochrane Collaboration RevMan version 5.3.

In cases that multiple studies reported on the same population (i.e., patients from the same hospital), only the larger study or the one with the longest follow-up was included in the meta-analysis.

Quality and publication bias evaluation

The Newcastle-Ottawa Quality Assessment Scale (NOS) was used as an evaluation tool to assess nonrandomized controlled trials (non-RCTs). The scale’s range varies from 0 to 9 stars. Studies evaluated with a score equal to or higher than 5 were considered to have adequate methodological quality and were included. There were no RCTs in the literature to be included. Two investigators (D.E.M. and V.S.T.) rated the included studies independently and final decision was reached by consensus.

The risk of publication bias was evaluated using the Egger’s formal statistical test because the number of the studies that were included in the analysis was not adequate (less than 10). As a result, the power of the test was substantially compromised.

Results

Article selection and patient demographics

The flow diagram of the systematic literature search is shown in Figure 1 and the PRISMA checklist in Supplementary Table S1 (Supplementary Data are available online at www.liebertpub.com/lap). Among the 150 articles in PubMed, Scopus, and CENTRAL that were retrieved, 21 articles were included in the qualitative synthesis. Nine studies12,17,18,20,22–24,27,28 were comparative and were included in the quantitative analysis. The study design was retrospective in 149–11,13–17,20–23,27,28 and prospective in 7 studies12,18,19,24–26,29. The included studies were conducted in Italy,9,24 Spain,12 Chile,13,14,19 France,15,21,25,26 Taiwan,16 United States,17,20,22,23,27 India,18 Austria,28 and Greece.10,11,29 and were published between 2010 and 2016. The SILSG study population ranged from 12 to 1000 patients. The total study population was 3843 patients; 1815 patients were treated with LSG and 2028 patients were treated with SILSG. Preoperative mean BMI was >30 kg/m² in all included patients. The baseline characteristics of studies comparing the outcomes between patients treated with either LSG or SILSG are provided in Table 1. The main comorbidities are demonstrated in Supplementary Table S2. The Newcastle-Ottawa rating scale assessment for all studies is shown in Table 1. Perioperative and postoperative outcomes are presented in Table 2. Pooled ORs, I², along with P values of heterogeneity for all outcomes that were measured are summarized in Table 3.

Single-port devices and Bougie diameter

The single-port devices that were used in each study are described in Table 2. The most frequently used devices were LESS Triport/Quadport (Olympus Medical, Nagano, Japan) in six studies,9,12,15,17,25,26 Codivien SILS-TM Port (Codivien Surgical, Mansfield, MA) in six studies,12,13,18,23,24,27 and Gelport/Geolpoint (Applied Medical, Rancho Santa Margarita, CA) in three studies.13,14,28 The use of bougie as a guide to the lesser curvature was also assessed in this study (Table 2). Bougie was used in the following diameters: 32F,12,21,23 34F,17,27 and 36F,13–16,18,19,23,25,26,28

Mean operative time

The mean operative time ranged from 42 to 118.2 minutes regarding the LSG group and from 45 to 151.7 minutes regarding the SILSG group (Table 2). Moreover, the mean operative time was similar in both groups [WMD: −5.98 (−12.51 to 0.54); P = .07] as shown in Table 3 and Figure 2.

Length of hospital stay

The median length of hospital stay ranged from 1.4 to 6 days for the LSG group and from 1.7 to 5 days for the SILSG group (Table 2). According to our analysis (Table 3 and Fig. 2), the median length of hospital stay was similar in both groups [WMD: 0.06 (−0.23 to 0.34); P = .69].
Doses of analgesics and reported pain

Five studies assessed the doses of administered analgesics, as shown in Table 2. No statistically significant difference was reported [WMD: −9.40 (95% CI: −29.39 to 10.59); P = .36]. According to Porta et al., postoperative visual analogue scale (VAS) regarding pain assessment was comparable between the LSG and SILSG groups (P = .46 on day 1; P = .12 on day 2; and P = .90 on day 3). Park et al. also showed that pain score was comparable between the two groups at 12 and 24 hours postoperatively (P = .519 and P = .403, respectively). However, Lakdawala et al. presented that 24% of the patients in the LSG group needed painkillers after discharge, while no patient in the SILSG needed (P < .0001). This is in accordance with another study that found significantly less reported pain in the SILSG group (P = .003). Finally, in their noncomparative study, Alevizos and Lirici reported relatively low postoperative pain VAS score regarding patients treated with SILSG.

Conversions

The conversion rate regarding the LSG group was 0% in all the studies that were included, except from one study in which the conversion rate was 1.96%, as shown in Table 2. In the SILSG group, the number of conversions to conventional multiport laparoscopic approach was 0 in 9 studies, and 1 in 5 studies, and 2 in 2 studies with the conversion rate ranging from 0% to 5%. There was only one case of conversion to open surgery in the SILSG group. The reasons for conversion from SILSG to either conventional laparoscopic or open surgery are shown in Supplementary Table S3.

Complications, reoperations, and mortality

Leaks were encountered in two studies and no statistically significant difference was found [OR: 0.43 (95% CI 0.06–2.95); P = .39] (Fig. 3). The risk of bleeding was also comparable between the two groups [OR: 0.65 (95% CI 0.17–2.58); P = .54] (Fig. 3). Furthermore, the incidence of wound infection was similar [OR: 0.51 (95% CI 0.10–2.49); P = .40] (Fig. 3). Moreover, the incidence of new development of postoperative gastroesophageal reflux disease was comparable for the two groups [OR: 1.87 (95% CI 0.38–9.29); P = .45]. Only two studies reported cases with incisional hernia in the SILSG group ranging from 1% to 3.7%, and no incisional hernias were reported for the LSG group according to the comparative study. The hernia was diagnosed by computed tomography in the first study, while in the second, there is no available information relative to the diagnostic workup. The incidence of reoperation was low in both approaches ranging from 0% to 4.5% for LSG and from 0% to 10% for SILSG. No significant difference was reported.
Table 1. Characteristics of the Studies That Were Finally Included in the Systematic Review and Meta-Analysis

<table>
<thead>
<tr>
<th>Study ID (year), type of study</th>
<th>Journal</th>
<th>Country</th>
<th>Time period</th>
<th>Type of comparison</th>
<th>Patients, n</th>
<th>Female, n (%)</th>
<th>Mean age</th>
<th>Mean preoperative BMI (range), kg/m²</th>
<th>Stars in Ottawa²³</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alexandrou (2015), R¹⁰</td>
<td>The American Journal of Surgery</td>
<td>Greece</td>
<td>1/2004–7/2008</td>
<td>LSG</td>
<td>25</td>
<td>18 (72%)</td>
<td>41.3±2.4</td>
<td>55.5±1.7</td>
<td>—</td>
</tr>
<tr>
<td>Alexandrou (2015), R¹¹</td>
<td>Obes Surg</td>
<td>Greece</td>
<td>6/2012–8/2014</td>
<td>LSG</td>
<td>100</td>
<td>79 (79%)</td>
<td>50.3±7.6</td>
<td>38.8±11.1</td>
<td>—</td>
</tr>
<tr>
<td>Farias (2013), R¹³</td>
<td>Obes Surg</td>
<td>Chile</td>
<td>7/2010–5/2012</td>
<td>SILSG</td>
<td>— 237</td>
<td>221 (93.2)</td>
<td>36±10.2</td>
<td>33.5±3.3</td>
<td>—</td>
</tr>
<tr>
<td>Fernández (2014), R¹⁴</td>
<td>Obes Surg</td>
<td>Chile</td>
<td>12/2012–3/2013</td>
<td>SILSG</td>
<td>— 74</td>
<td>72 (97%)</td>
<td>34.2±9.2</td>
<td>—</td>
<td>34.0±3.2</td>
</tr>
<tr>
<td>Ghinagow (2013), R¹⁶</td>
<td>Obes Surg</td>
<td>USA</td>
<td>N/A</td>
<td>LSG versus SILSG</td>
<td>36</td>
<td>29</td>
<td>46 (31–72)</td>
<td>43.3±4.3</td>
<td>43.72 (34–50)</td>
</tr>
<tr>
<td>Lakdawala (2014), P¹⁷,M</td>
<td>Obes Surg</td>
<td>India</td>
<td>9/2009–1/2012</td>
<td>LSG versus SILSG</td>
<td>300</td>
<td>150 (50)</td>
<td>35.5±7.8</td>
<td>39.9±5.1</td>
<td>39.9±5.2</td>
</tr>
<tr>
<td>Maltuenda (2014), P¹⁸,M</td>
<td>Eur Surg</td>
<td>Chile</td>
<td>N/A</td>
<td>SILSG</td>
<td>— 20</td>
<td>— 20 (100)</td>
<td>34.5 (21–57)</td>
<td>35.1 (30.5–40)</td>
<td></td>
</tr>
<tr>
<td>Muir (2015), R¹⁹,M</td>
<td>Surg Endosc</td>
<td>USA</td>
<td>8/2011–9/2013</td>
<td>LSG versus SILSG</td>
<td>30</td>
<td>32</td>
<td>96.9%</td>
<td>46.5</td>
<td>42.1</td>
</tr>
<tr>
<td>Nocca (2016), R²²</td>
<td>Surg Endosc</td>
<td>France</td>
<td>1/2005–6/2013</td>
<td>LSG</td>
<td>1050</td>
<td>— 72.86%</td>
<td>44.5±7.7</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td>Park (2012), R²³,M</td>
<td>Surg Obes Relat Dis</td>
<td>USA</td>
<td>3/2009–12/2010</td>
<td>LSG versus SILSG</td>
<td>9</td>
<td>8</td>
<td>47.9±14</td>
<td>48.5±9.3</td>
<td>47.1±6.6</td>
</tr>
</tbody>
</table>

(continued)
**Table 1. (continued)**

<table>
<thead>
<tr>
<th>Study ID (year), type of study</th>
<th>Journal</th>
<th>Country</th>
<th>Time period</th>
<th>Type of comparison</th>
<th>Patients, n</th>
<th>Female, n (%)</th>
<th>Mean age</th>
<th>Mean preoperative BMI (range), kg/m²</th>
<th>Stars in Ottawa&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Porta (2016), P&lt;sup&gt;24,M&lt;sup&gt;</td>
<td>Obes Surg</td>
<td>Italy</td>
<td>1/2009–12/2014</td>
<td>LSG versus SILSG</td>
<td>65</td>
<td>65</td>
<td>51</td>
<td>39 ± 2.3</td>
<td>41.01 ± 0.4</td>
</tr>
<tr>
<td>Pourcher (2015), P&lt;sup&gt;26&lt;sup&gt;</td>
<td>Surg Obes Relat Dis.</td>
<td>France</td>
<td>2012–2013</td>
<td>SILSG</td>
<td>—</td>
<td>16</td>
<td>N/A</td>
<td>17.8 ± 1.9</td>
<td>—</td>
</tr>
<tr>
<td>Saber (2010), R&lt;sup&gt;27,M&lt;sup&gt;</td>
<td>Surg Obes Relat Dis.</td>
<td>USA</td>
<td>9/2008–8/2009</td>
<td>LSG versus SILSG</td>
<td>12</td>
<td>14</td>
<td>7</td>
<td>43.1 ± 13.6</td>
<td>52.6 ± 6.8</td>
</tr>
<tr>
<td>Sucher (2014), R&lt;sup&gt;28,M&lt;sup&gt;</td>
<td>J Laparoendosc Adv Surg</td>
<td>Austria</td>
<td>1/2011–5/2012</td>
<td>LSG versus SILSG</td>
<td>40</td>
<td>40</td>
<td>40</td>
<td>34 (24–73)</td>
<td>43.8 (35.0–47.8)</td>
</tr>
</tbody>
</table>

The first author of every study along with the year of publication, the journals, the country of origin, the time period of the study, the comparison of techniques, the study design, the number of participants, and the number of female patients, along with the mean age, mean preoperative BMI, and the number of stars according to the Newcastle-Ottawa Quality Assessment Scale.

<sup>a</sup>The Newcastle-Ottawa Scale for assessing the quality of nonrandomized studies. Every study is judged on three perspectives: the selection, the comparability, and the ascertainment of the exposure of the study groups. The highest quality studies are awarded up to 9 stars.

<sup>M</sup>Included in meta-analysis (quantitative analysis).

BMI, body mass index; R, retrospective; P, prospective; LSG, laparoscopic sleeve gastrectomy; N/A, not available; SILSG, single-incision laparoscopic sleeve gastrectomy.
Table 2. Summary of the Assessment of the Intraoperative Parameters and Outcomes of Every Study that was Included in the Systematic Review and Meta-Analysis

<table>
<thead>
<tr>
<th>Study ID (year)</th>
<th>Bougie diameter</th>
<th>Mean operative time, minutes (range)</th>
<th>Mean hospital stay, days (range)</th>
<th>Conversion rate, n (%)</th>
<th>Doses of analgesics, mg</th>
<th>Reoperation, n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alevizos (2012)&lt;sup&gt;9,a&lt;/sup&gt;</td>
<td>32F*</td>
<td>—</td>
<td>151.7 (100–185)</td>
<td>—</td>
<td>44.5 (28–60)</td>
<td>—</td>
</tr>
<tr>
<td>Alexandrou (2015)&lt;sup&gt;10&lt;/sup&gt;</td>
<td>Endoscope equivalent to 29F bougie</td>
<td>115.5 (90–150)</td>
<td>—</td>
<td>4.5 (4–16)</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Alexandrou (2015)&lt;sup&gt;11&lt;/sup&gt;</td>
<td>Endoscope equivalent to 29F bougie</td>
<td>114</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Delgado (2012)&lt;sup&gt;12,a,b,M&lt;/sup&gt;</td>
<td>32F</td>
<td>54.1 (40–90)</td>
<td>79.2 (50–130)</td>
<td>—</td>
<td>2.75</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Farias (2013)&lt;sup&gt;13,b,c&lt;/sup&gt;</td>
<td>36F</td>
<td>—</td>
<td>49.5 ± 14.9</td>
<td>—</td>
<td>2.2 ± 1</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Fernández (2014)&lt;sup&gt;14,c&lt;/sup&gt;</td>
<td>36F</td>
<td>—</td>
<td>48 ± 10</td>
<td>—</td>
<td>2.4 ± 2.0</td>
<td>—</td>
</tr>
<tr>
<td>Gailhard (2016)&lt;sup&gt;15,a,d&lt;/sup&gt;</td>
<td>36F</td>
<td>—</td>
<td>112 (50–360)</td>
<td>—</td>
<td>4 (2–125)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Ghinagow (2013)&lt;sup&gt;16,e&lt;/sup&gt;</td>
<td>36F</td>
<td>—</td>
<td>72 ± 27.91</td>
<td>—</td>
<td>2 ± 0.84</td>
<td>0 (0)</td>
</tr>
<tr>
<td>GoÌberawalla (2014)&lt;sup&gt;17,a,M&lt;/sup&gt;</td>
<td>34F</td>
<td>118.25 (57–218)</td>
<td>116.78 (79–197)</td>
<td>1.75 (1–3)</td>
<td>1.80 (1–3)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Lakdawala (2014)&lt;sup&gt;18,b,M&lt;/sup&gt;</td>
<td>36F</td>
<td>42 ± 18.2</td>
<td>45 ± 20.5</td>
<td>—</td>
<td>—</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Maluenda (2014)&lt;sup&gt;19,f&lt;/sup&gt;</td>
<td>36F</td>
<td>—</td>
<td>127 (90–170)</td>
<td>—</td>
<td>—</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Muír (2015)&lt;sup&gt;20,g,M&lt;/sup&gt;</td>
<td>N/A</td>
<td>90.7 (40–139)</td>
<td>104.6 (68–165)</td>
<td>N/A</td>
<td>1.4±0.6</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Nguyen (2012)&lt;sup&gt;21,M&lt;/sup&gt;</td>
<td>32F</td>
<td>78 ± 26</td>
<td>84 ± 24</td>
<td>1.8 ± 0.7</td>
<td>0 (0)</td>
<td>1 (0)</td>
</tr>
<tr>
<td>Nocca (2016)&lt;sup&gt;22&lt;/sup&gt;</td>
<td>36F</td>
<td>—</td>
<td>—</td>
<td>5.3 ± 4.6</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Park (2012)&lt;sup&gt;23,b,M&lt;/sup&gt;</td>
<td>32F</td>
<td>101.1 ± 31.3</td>
<td>118.4 ± 30.7</td>
<td>62.7 ± 12.8</td>
<td>59.1 ± 17.1</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Porta (2016)&lt;sup&gt;24,b,M&lt;/sup&gt;</td>
<td>36F</td>
<td>61 ± 11</td>
<td>60 ± 15</td>
<td>3.1 (2–11)</td>
<td>3 (2–5)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Poucher (2013)&lt;sup&gt;25,a&lt;/sup&gt;</td>
<td>36F</td>
<td>—</td>
<td>86 (52–205)</td>
<td>—</td>
<td>4 (3–9)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Poucher (2015)&lt;sup&gt;26,a&lt;/sup&gt;</td>
<td>36F</td>
<td>—</td>
<td>66 (52–112)</td>
<td>—</td>
<td>4 (3–9)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Sabeí (2010)&lt;sup&gt;27,b,M&lt;/sup&gt;</td>
<td>36F</td>
<td>110 ± 33.4</td>
<td>128 ± 19.3</td>
<td>2.3 ± 0.7</td>
<td>1.7 ± 0.7</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Sucher (2014)&lt;sup&gt;28,c,d,M&lt;/sup&gt;</td>
<td>36F</td>
<td>97.4 ± 26.0</td>
<td>84.8 ± 21.3</td>
<td>6 ± 14</td>
<td>5 ± 24</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Zacharoulis (2012)&lt;sup&gt;29&lt;/sup&gt;</td>
<td>36F</td>
<td>92 (50–240)</td>
<td>—</td>
<td>5.9 (4–13)</td>
<td>2 (1.96)</td>
<td>—</td>
</tr>
</tbody>
</table>

The Bougie diameter, the mean operative time, the mean hospital stay, the conversion rate, the administered doses of analgesics, and the incidence of reoperations, along with the % excess weight loss (%EWL) in 3, 6, 12, and 24 months are demonstrated where available.

*LESS Triport/Quadport (Olympus Medical, Nagano, Japan).
**Covidien SILS™ Port (Covidien Surgical, Mansfield, MA).
*Gelport/Gelpoint (Applied Medical, Rancho Santa Margarita, CA).
*Octoport (Landanger, Chaumont, France).
*Versaport plus V2 trocar (Covidien).
*SSL™ (Ethicon Endo-Surgery, Cincinnati, OH).
*SPIDER® (Transenterix Surgical, Inc., Durham, NC).
*Included in meta-analysis (quantitative analysis).
+F, French; **Conversion to open; ***mg/kg.
LSG, laparoscopic sleeve gastrectomy; N/A, not available; SILSG, single-incision laparoscopic sleeve gastrectomy.

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The main reasons for reoperation included leak and bleeding. Mortality was 0 in 16 out of 17 studies. In only one study,15 mortality was 0.1% (n = 1 patient) in the SILSG approach due to pulmonary embolism on postoperative day 10.

Cosmetic results at 3 months postoperatively were evaluated by Sucher et al.28. Cosmesis was significantly better for the SILSG patients (P < .01). According to Lakdawala et al.,18 patients treated with SILSG were more satisfied regarding cosmetic outcome compared to LSG at 6 months postoperatively. According to another study,24 cosmetic outcome was higher in the SILSG group (P = .041).

### Publication bias

Heterogeneity was high regarding mean operative time, mean hospital time, and doses of analgesics. Furthermore,
heterogeneity was low regarding complications, conversions, and reoperations. Funnel plots regarding mean operative time (Supplementary Fig. S2), mean hospital stay (Supplementary Fig. S3), along with incidence of leaks (Supplementary Fig. S4), bleeding (Supplementary Fig. S5), and wound infection (Supplementary Fig. S6) seemed asymmetrical, with studies being absent from either top or bottom of the graph, thus posing certain publication bias. The small number of the included studies was the main reason of the reported asymmetry. Egger test could not be performed because of the inadequate number of studies that were included.

Discussion
The increasing popularity of LSG as a standalone procedure for morbid obesity has led to the introduction of novel alternative approaches, either robotic or single-incision laparoscopic. This meta-analysis identified 21 articles assessing LSG and SILSG as two alternative surgical techniques, measuring patients’ outcomes and published from 2010 to 2016. No similar meta-analysis was identified through literature search. The evidence summarized in this study brings us closer to linking the implementation of either method with enhanced standards of safety, feasibility, and cost-effectiveness.

This study demonstrates that both LSG and SILSG are well-tolerated and feasible surgical procedures. The single-incision surgical technique can be performed with either single-port devices or with multiple trocars through a skin incision. In the included studies, a wide variety of single-port devices were used. In fact, these are multichannel platforms with accesses for flexible instruments. The majority of those devices require different arrangements for the orientation of the instruments. However, the single-port device SPIDER (Transenterix Surgical, Inc., Durham, NC) that was used by Muir and Rice offers true instrument triangulation, simulating conventional LSG. The loss of triangulation in the restricted space of the abdominal cavity during a
single-incision surgical operation increases the difficulty for the operator. In this sense, it is crucial to assess its effect on the mean operative time. Despite the increased difficulty, the mean operative time was similar between the LSG and SILSG groups.

Conversion rate was low in all studies. Conversion to conventional multiport approach ranged from 0% to 16.5% regarding patients treated with SILSG. Conversion to open surgery was reported in only one study\(^\text{15}\) and involved one patient (0.1%). According to our analysis, conversion rate was similar between the two groups. Two possible reasons explaining those low rates in the SILSG might be the high experience level of the surgeons who performed SILSG and the use of an additional trocar of 3–5 mm in cases that this was essential for the safety of the patient.

Incisional hernia constitutes a great concern regarding single-incision surgical approach. Historically, single-incision laparoscopic technique has been associated with significantly increased total hernia rates compared to conventional laparoscopic approach.\(^\text{32}\) This was in accordance with two\(^\text{15,16}\) of the included studies in which it ranged from 1% to 3.7%. It should be highlighted that in both studies,\(^\text{18}\) the study population was relatively large (1000 and 300 patients, respectively) compared to the other studies. In contrast, other included studies with smaller study population and shorter follow-up period reported hernia rates of ~0%. This is a strong indication that there is a certain trend toward increased hernia rates regarding SILSG. More RCTs with greater population are needed to assess rare events such as incisional hernias.

Both procedures were associated with small and comparable rates of complications and conversions, being significantly safe. In addition, leaks and hemorrhage are the main perioperative risks of bariatric surgical procedures, due to the long stapled lines and gastrointestinal anastomoses. According to the outcomes of this study, the incidence of leaks and hemorrhage was similar between both study groups. No significant differences were reported.

The reoperation rate remains a certain concern when a novel technique is assessed. In this study, the reoperation rate was comparable for both techniques. Mortality was zero in most studies for both techniques. In only one study,\(^\text{15}\) one case of perioperative death was reported from a total of 1000 patients who were treated with SILSG. Length of hospital stay was also comparable for the two groups.

The cosmetic result and the reduction of pain are two theoretical advantages of SILSG. In all studies assessing the cosmetic outcome, patients who underwent SILSG were significantly more satisfied than those in the LSG group. The results regarding pain measurement were not clear with some studies\(^\text{15,27}\) reporting a significant decrease in the SILSG group and other studies showing comparable results.\(^\text{23,24}\) According to Lai et al.,\(^\text{33}\) while postoperative pain was similar between single-incision and conventional laparoscopic cholecystectomy 6 hours after surgery, the pain score was worse in single-incision group on postoperative day 7. A similar observation would be possible if the follow-up period and the sample size were greater. The administered doses of analgesics were comparable for the two groups. It should be noted that the provided data were very heterogeneous regarding the methods assessing pain and administered analgesics, and certain publication bias is present.

Bariatric surgery is the main therapeutic modality to succeed weight loss and enhancement of the metabolic profile.\(^\text{34}\)

Since both examined techniques are different approaches of the same operation, the significance of comparing weight loss outcomes is minimal. As a result, we did not assess %EWL in this study.

This meta-analysis demonstrates the need for further studies comparing LSG with the SILSG. Ideally, these would be RCTs with long-term follow-up. Regarding rare events, such as incisional hernias and conversions, a larger study population and longer follow-up period are needed.

The limitations of this meta-analysis reflect the limitations of the studies that were included. Seven studies\(^\text{12,18,19,24–26,29}\) were prospective. There were no RCTs between the comparative studies included, thus posing a certain limitation in this study. The majority of the studies included\(^\text{9–11,13–17,20–23,27,28}\) were retrospective. The small number of included studies poses a publication bias, as it reflects to the asymmetry of funnel plots.

Nonetheless, the strengths of this study are (1) the clear data extraction protocol, (2) the well-specified inclusion–exclusion criteria, (3) the search in three different literature databases, (4) the quality assessment of the included studies, and (5) the detailed demonstration of the outcomes.

Conclusions

This meta-analysis identified 21 unique studies that compared LSG and SILSG procedures. These studies suggest that LSG and SILSG are associated with comparable clinical outcomes. Mean operative time and length of hospital stay were similar for both groups, but were associated with high heterogeneity. Complications were comparable and a trend of increased hernia rates was reported in the single-incision approach. Only few studies assessed satisfaction regarding the cosmetic result, which was greater in the SILSG group. According to our findings, the SILSG approach has not been proven to provide enhanced outcomes to counterbalance the increased incisional hernia risk. These results should be interpreted with caution due to the lack of RCTs. Future studies with increased clarity in significant outcomes, as complications, mortality, pain reduction, and hernia rate, are necessary to demonstrate the differences in efficacy between LSG and SILSG.

Disclosure Statement

No competing financial interests exist.

References

5. Liberati A, Altman DG, Tetzlaff J, et al. The PRISMA statement for reporting systematic reviews and meta-analyses of


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