A Prospective, Randomized Controlled Trial of Single-Incision Laparoscopic vs Conventional 3-Port Laparoscopic Appendectomy for Treatment of Acute Appendicitis

Jonathan T Carter, MD, FACS, Jennifer A Kaplan, MD, Jason N Nguyen, BA, Matthew YC Lin, MD, Stanley J Rogers, MD, FACS, Hobart W Harris, MD, MPH, FACS

BACKGROUND: Proponents of single-incision laparoscopic surgery (SILS) claim patients have less pain, faster recovery, and better long-term cosmetic results than patients who undergo multiport laparoscopy. However, randomized comparisons are lacking. This study presents the results of a prospective randomized trial of SILS or 3-port laparoscopic appendectomy.

STUDY DESIGN: Adults with uncomplicated acute appendicitis were randomized 1:1 to either SILS or 3-port laparoscopic appendectomy. The primary end point was early postoperative pain (measured by opiate usage and pain score in the first 12 hours). Secondary end points were operative time, complication rate (including conversions), and recovery time (days of oral opiate usage and return to work). After 6 months, body image and cosmetic appearance were assessed using a validated survey.

RESULTS: The trial was planned for 150 patients, but was halted after 75 patients when planned interim analysis showed that SILS patients had more postoperative pain (pain score: 4.4 ± 1.6 vs 3.5 ± 1.5; p = 0.01) and higher inpatient opiate usage (hydromorphone use: 3.9 ± 1.9 mg vs 2.8 ± 1.7 mg; p = 0.01) than 3-port laparoscopy. Operative time for SILS averaged 40% longer (54 ± 17 minutes vs 38 ± 11 minutes; p < 0.01). Only 1 SILS case was converted to 3-port. There were no significant differences in length of stay, complications, oral pain medication usage after discharge, or return to work. After 6 months, body image and cosmetic appearance were excellent for both groups and indistinguishable by most measures. However, 3-port patients reported better physical attractiveness (4.0 ± 0.4 vs 3.8 ± 0.4; p = 0.04) and SILS patients reported better scars (score 18.4 ± 2.7 vs 16.4 ± 3.0; p < 0.01). Results are reported as mean ± SD.

CONCLUSIONS: Single-incision laparoscopic surgery appendectomy resulted in more pain and longer operative times without improving short-term recovery or complications. Long-term body image and cosmetic appearance were excellent in both groups. (J Am Coll Surg 2014;218: 950–959. © 2014 by the American College of Surgeons)

Recent advances in laparoscopic instrumentation have made it possible to perform intra-abdominal operations entirely through a small incision that can be hidden within the umbilicus. The goal is to perform surgery with fewer incisions and no visible scars. Potential benefits are faster recovery, less pain, fewer wound complications, better long-term cosmetic results, and no need to violate a natural orifice. The term SILS, for single-

CME questions for this article available at http://jacsctme.facs.org

Disclosure Information: Authors have nothing to disclose. Timothy J Eberlein, Editor-in-Chief, has nothing to disclose.

This study was supported with a University of California, San Francisco Research Evaluation and Allocation Committee Grant.

Registered in ClinicalTrials.gov identifier: NCT00997516.


Received October 29, 2013; Revised December 23, 2013; Accepted December 30, 2013.

From the Department of Surgery, University of California, San Francisco, San Francisco (Carter, Kaplan, Lin, Rogers, Harris) and Department of Molecular and Cell Biology, University of California, Berkeley, Berkeley (Nguyen), CA.

Correspondence address: Jonathan T Carter, MD, FACS, Department of Surgery, University of California, San Francisco, 521 Parnassus Ave, C341, San Francisco, CA 94143. email: jonathan.carter@ucsfmedctr.org
incision laparoscopic surgery, is being used to describe such techniques, and many have touted SILS as a major breakthrough in minimally invasive surgery.

In the past 5 years, SILS techniques have been developed to perform cholecystectomy, appendectomy, hysterectomy, bariatric procedures, hernia repair, fundoplication, colectomy, and nephrectomy. Some have suggested that SILS is a better strategy than natural orifice transluminal endoscopic surgery to provide “scarless” surgery because SILS can be performed with conventional laparoscopic instrumentation, there is no need to perforate the vagina or a hollow viscus, and most laparoscopic surgeons already possess the necessary skills. Single-incision laparoscopic surgery has received major industry attention; in January 2009, the first SILS port and trocar system (SILS Port; Covidien) received FDA approval and began marketing in the United States, followed quickly by other similar devices.

On the other hand, results of conventional multiport laparoscopy are already excellent, and direct comparisons of SILS with conventional laparoscopy are lacking. Because SILS requires a larger incision than a standard laparoscopic incision, some have wondered if SILS might actually cause more pain, more wound complications, and longer recovery. Others have questioned whether elimination of 5-mm ports translates into improved cosmetic appearance because 5-mm scars are often barely noticeable after a year.

Only 2 studies have prospectively compared SILS with multiport laparoscopic procedures for appendectomy, neither of which assessed long-term cosmetic appearance. The literature consists mostly of retrospective case series that lack a control population. We conducted a prospective, randomized controlled trial of SILS vs conventional 3-port laparoscopic appendectomy for the treatment of acute appendicitis. We hypothesized that SILS patients would experience less pain and have better long-term cosmetic outcomes than 3-port laparoscopic patients.

**METHODS**

**Study design**

This was a single-center, prospective, equally randomized (1:1), unblinded, parallel-group study designed to assess the superiority of SILS appendectomy to conventional 3-port laparoscopic surgery with respect to postoperative pain. The trial was approved by an IRB and registered as ClinicalTrials.gov identifier: NCT00997516.

**Participants**

The study population consisted of all patients from May 2010 to November 2012 who presented to the University of California, San Francisco emergency department and were diagnosed with acute appendicitis on the basis of clinical and radiographic evaluation. Patients who met the inclusion and exclusion criteria (Table 1) were invited to participate in the trial and were enrolled by the principal investigator. After providing informed consent, patients received intravenous fluids and preoperative broad-spectrum antibiotics to cover gram-negative rods and anaerobes.

Patients were then assigned to conventional laparoscopic appendectomy or SILS appendectomy in a 1:1 ratio by a computerized random number generator (http://www.random.org). A random number between 1 and 1000 was picked; even-numbered patients received 3-port laparoscopic appendectomy, odd-numbered patients received SILS appendectomy. There was no blocking or stratification variables used during randomization. Randomization occurred after informed consent was obtained from the patient and before induction of anesthesia. The patient was unaware of the randomization until after the completion of the operation.

**Interventions and surgical technique**

All operations were performed by a single surgeon (JTC) experienced in both 3-port and SILS appendectomy. The study surgeon had performed >25 SILS and 3-port appendectomies before the start of the trial.

For conventional laparoscopic appendectomy, patients were placed in the supine position and a general anesthetic was given. An orogastric tube, sequential compression devices, and Foley catheter were placed. The left arm was tucked and the abdomen shaved as necessary. The umbilical skin was anesthetized with 5 mL 0.25% Marcaine. A 15-mm vertical incision was made within the umbilical stalk, the fascia was retracted, and a 15-mm vertical fascia incision was made. A 12-mm Hasson port was placed through the fascia and the abdomen insufflated to 15 mmHg with carbon dioxide gas. Diagnostic laparoscopy was then performed. If a diagnosis other than acute appendicitis was made (such as pelvic inflammatory disease, sigmoid diverticulitis, cecal diverticulitis, Crohn’s disease, perforated duodenal ulcer), the patient was excluded from the study and treated appropriately. After the abdominal wall was anesthetized with 0.25% Marcaine, additional 5-mm ports were placed in the left lower quadrant and suprapubic midline. The appendix was exposed and retracted anteriorly. The mesoappendix was divided with sequential fires of a cutting-and-sealing device (Ligasure; Covidien). The base of the appendix was ligated with a linear stapler or looped suture. The appendix was removed through the umbilical incision after first placing it into a sterile bag. Minimal irrigation was used; perforated cases were treated with...
suctioning of intra-abdominal pus and postoperative antibiotics. Blood loss was estimated. Umbilical fascia was closed with slowly absorbable suture. The skin edges were reapproximated with slowly absorbable suture, and skin glue was the only dressing.

For SILS appendectomy, patients were prepared and positioned the same as for 3-port appendectomy. The base of the umbilical stalk was everted by 2 penetrating towel clamps placed on either side of the midline. The skin was anesthetized with 5 mL 0.25% Marcaine. A vertical skin incision was made within the umbilical stalk, the fascia was retracted, and a 30-mm vertical fascia incision was made with a scalpel. The peritoneum was entered with a gloved finger, Kelly clamp, or scissors. The incision was retracted
anteriorly with a retractor, and a SILS device (SILS Port; Covidien) was inserted into the incision using a shoehorn maneuver. Five-millimeter trocars were placed and the abdomen insufflated to 15 mmHg with carbon dioxide gas, after which the trocars were repositioned into a staggered elevation. Diagnostic laparoscopy and appendectomy was then performed with the same instruments as before, typically using standard nonarticulating laparoscopic instrumentation. The fascia was closed with slowly absorbable simple interrupted sutures, typically 5 or 6. Skin was reaproximated with slowly absorbable monofilament suture and the incision was dressed with skin glue.

After surgery, patients were given a full liquid diet immediately, and were advanced to an unrestricted diet as soon as the patient was up to it. Pain was controlled by a hydromorphone patient-controlled analgesia pump for at least 12 hours after discharge from the recovery room, after which oral pain medications were prescribed. No steroids (eg, Decadron) or NSAIDS were used. Antibiotics for appendicitis were given at the discretion of the attending surgeon. Patients were discharged when they could eat without vomiting, their pain was controlled with oral medications, and the systemic inflammatory response had subsided.

After 2 to 3 weeks, the patients returned for a clinic appointment and their wounds were assessed for the presence of infection, seroma, or hernia. Date of return to work and date of last opiate pain medication were recorded. After a minimum of 6 months, patients completed the Body Image Questionnaire (Fig. 1) and Cosmetic Appearance Scale (Fig. 2). The 2 surveys were developed to assess body image and appearance after surgical procedures that result in visible scars.

**Outcomes**

The study variables were defined prospectively and are listed in Table 1. The primary outcomes measure was pain in the first 12 hours after surgery, as assessed by patient-controlled analgesia hydromorphone use and pain score. Long-term outcomes were assessed using the Body Image Questionnaire (Fig. 1), which is a validated survey that measures patients’ perceptions of and satisfaction with their own bodily appearance. Five questions were asked, with 4 answers per question. The Cosmetic Appearance Scale (Fig. 2) assessed the degree of satisfaction with the physical appearance of the abdomen (and its scars) using a visual analogue scale. Numeric scores were obtained by measuring the horizontal distance from the low end of the scale to the marking, and then normalized on a 20-point scale. There were no changes to the trial outcomes measures after the trial commenced.

**Sample size and statistical analysis**

Our institutional statisticians were consulted for study design and power calculations. For the study, 150 patients were planned, with approximately 75 patients randomized to each arm. This study size had >90% power to detect a 1-point difference in mean pain score, assuming a 2-sided $\alpha$ of 0.05. Continuous variables are reported as mean ± SD and were compared using the $t$-test. Ordinal variables (ie, 6-month survey results) were compared using the Mann-Whitney U test. Categorical variables were compared using either Fisher’s exact test or chi-square test. Differences were considered significant when 2-sided $p$ value was $< 0.05$.

According to the study protocol, postoperative pain (the primary result) and complications were reviewed for every 25 patients enrolled, and then reported to the University of California, San Francisco Committee on Human Research (our IRB). Interim analysis was performed using Pocock stopping boundaries, with $p ≤ 0.01$ for each interim analysis. The trial was halted after 75 patients because interim analysis showed that SILS patients (the study group) had more postoperative pain and higher inpatient opiate use use.
than 3-port laparoscopic patients (the control group). Therefore, SILS was inferior with respect to the primary end point.

RESULTS

Patient accrual and randomization
A flow diagram of the study design is shown in Figure 3. A total of 75 patients were randomized into the trial and underwent SILS or 3-port appendectomy. No patient crossed over to a different treatment arm after randomization, and all completed short-term follow-up. Eight patients were lost to long-term follow-up.

Patient and procedure characteristics
The randomization was successful in creating study populations similar in age, weight, height, body mass index, sex, white blood cell count, and surgical history (Table 2). Only 1 procedure required conversion; a patient randomized to SILS required 2 additional ports to complete the operation because of intraoperative discovery of perforated retrocecal appendicitis. This patient was analyzed as part of the SILS group, in accordance with our intention-to-treat study design. All operations were completed safely and without inadvertent vascular or visceral injury. There were no deaths. As planned, fascia incision length was 15 mm longer for SILS patients, and typically required 5 or 6 simple interrupted sutures to close. Standard nonreticulating instruments were used in all of the procedures. Despite criteria designed to exclude patients with perforated appendicitis from the trial, there were 4 perforated cases in the SILS group and 3 in the 3-port group.
Operative time was 40% longer in the SILS group (54 vs 38 minutes; p < 0.01). During the 2-year trial, mean operative time (of 10 cases) did not change in either group from the beginning to the end of the trial.

**Pain and recovery**

The primary outcomes measure was pain in the first 12 hours after surgery, measured in complementary fashion by pain score and patient-administered hydromorphone use. By both measures, SILS patients experienced more pain (Table 3). The SILS patients reported a mean pain score of 4.4 of 10 in the first 12 hours after surgery, compared with 3.5 for 3-port patients (p = 0.01). Similarly, SILS patients used a mean of 3.9 mg hydromorphone in the first 12 hours after surgery, compared with 2.8 mg for 3-port patients (p = 0.01). After discharge from the hospital, duration of oral opiate use did not differ significantly between groups. Recovery was also similar; no significant differences in length of hospitalization or time off work were observed.

**Complications**

Patient complications were similar between groups (Table 3). The long-term development of umbilical hernia, an important complication, was not assessed in this trial because no physical examination was performed after 6 months. However, no umbilical hernias were self reported by study participants in the survey of outcomes after 6 months.

**Body image and cosmetic appearance**

After a minimum of 6 months, follow-up surveys were completed by 67 of 75 patients (89%). For the 5 measures of body image, results for both groups were outstanding and neared the upper limit of the measurement scale. The 3-port patients reported a slightly better physical attractiveness (all 3-port patients rated a perfect 4, compared with a mean of 3.8 for SILS patients; p = 0.04). Cosmetic appearance for both groups was also excellent. The SILS patients reported slightly improved overall scar, but not better abdominal appearance, scar appearance, satisfaction, or discomfort (Table 3).
DISCUSSION

Results of this randomized prospective trial showed that the SILS appendectomy took longer to perform; was associated with more pain; and did not consistently improve recovery, body image, or cosmetic appearance. In fact, when planned interim analysis showed that SILS was associated more postoperative pain (pain score: 4.4 vs 3.5; p = 0.01) and higher inpatient opiate usage (hydromorphone use: 3.9 vs 2.8 mg; p = 0.01) than 3-port laparoscopy, the trial was halted after 75 patients. Therefore, this report challenges whether SILS improves on multiport laparoscopy for appendectomy.

Although the idea of scarless surgery has broad popular appeal, very few prospective comparative studies of 3-port laparoscopic vs SILS appendectomy have been published, despite the >250,000 appendectomies performed annually in the United States.24 The current literature is mostly limited to case series reported retrospectively and without a control population. The first case report of SILS appendectomy was for a tubulovillous adenoma of the appendiceal orifice and used a single skin incision and 3 separate fascia incisions.25 The 40-minute operative time was similar to that of 3-port laparoscopy. In a series of 33 patients with acute appendicitis treated with SILS appendectomy, 2 cases were converted to 3-port laparoscopy and mean operative time was 41 minutes.26 In another series, 50 pediatric patients underwent SILS appendectomy and were compared retrospectively with 46 patients who underwent multiport laparoscopic appendectomy.27 Narcotic use was slightly lower in the SILS group (0.9 vs 1.4 doses; p = 0.01), but operative time was longer (34 vs 27 minutes; p = 0.01) and length of stay did not differ.27 These reports, which focused primarily on operative times, demonstrated the safety and technical feasibility of SILS appendectomy. They failed to show any advantage over conventional multiport laparoscopic appendectomy because there was no control group.

More recently, 2 prospective comparisons have been reported. Frutos and colleagues randomized 184 Spanish patients to SILS or multiport appendectomy and found SILS had longer operative times, more narcotic usage, more surgeon difficulty, and more cost, without reduced complications or faster recovery.17 Long-term cosmetic appearance was not measured.

Similar to both these published prospective and controlled trials, our study showed that SILS appendectomy took significantly longer than 3-port appendectomy. This did not appear to be the result of surgeon learning-curve bias because operative times did not change with

<table>
<thead>
<tr>
<th>Patient characteristics</th>
<th>SILS patients (n = 37)</th>
<th>3-Port patients (n = 38)</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, y, mean ± SD</td>
<td>34 ± 11</td>
<td>35 ± 12</td>
<td>0.63</td>
</tr>
<tr>
<td>Height, cm, mean ± SD</td>
<td>172 ± 11</td>
<td>174 ± 9</td>
<td>0.33</td>
</tr>
<tr>
<td>Weight, kg, mean ± SD</td>
<td>75 ± 14</td>
<td>78 ± 14</td>
<td>0.38</td>
</tr>
<tr>
<td>Body mass index, kg/m², mean ± SD</td>
<td>25 ± 4</td>
<td>25 ± 4</td>
<td>0.89</td>
</tr>
<tr>
<td>Sex, n (%)</td>
<td>19 (51)</td>
<td>24 (63)</td>
<td>0.35</td>
</tr>
<tr>
<td>White blood cell count, 10³ cells/µL, mean ± SD</td>
<td>14 ± 4</td>
<td>13 ± 4</td>
<td>0.18</td>
</tr>
<tr>
<td>Earlier operation in abdomen n (%)</td>
<td>3 (8)</td>
<td>4 (11)</td>
<td>&gt;0.99</td>
</tr>
<tr>
<td>umbilical fascial incision length, mm, mean ± SD</td>
<td>30 ± 1</td>
<td>15 ± 3</td>
<td>&lt;0.01*</td>
</tr>
<tr>
<td>No. of fascial sutures used, mean ± SD</td>
<td>6 ± 0.7</td>
<td>1.6 ± 1.1</td>
<td>&lt;0.01*</td>
</tr>
<tr>
<td>Duration of operation, min, mean ± SD</td>
<td>54 ± 17</td>
<td>38 ± 12</td>
<td>&lt;0.01*</td>
</tr>
<tr>
<td>Perforated or suppurative appendicitis, n (%)</td>
<td>4 (11%)</td>
<td>3 (8%)</td>
<td>0.71</td>
</tr>
</tbody>
</table>

Continuous variables are reported as mean ± SD and were compared using the t-test. Categorical variables were compared using either Fisher’s exact test or chi-square test.

*Significant.

SILS, single-incision laparoscopic surgery.
increasing surgeon experience in either arm of the trial during the 2-year study period. In other words, the study surgeon had already climbed the learning curve for both procedures before the trial began. We speculate that the longer operative times were the result of 2 factors. First, lack of triangulation to the target organ increased technical difficulty of the SILS approach. Second, the longer fascia incision took more time to close.

Although this trial was designed to enroll 150 patients, planned interim analysis performed after 75 patients demonstrated inferiority of SILS with regard to early postoperative pain (the primary end point). As a result, the trial was halted. Single-incision laparoscopic surgery patients experienced more pain, as measured by pain score and intravenous opiate usage. Hospitalization, oral opiate use after discharge, and time to work were not improved with the SILS approach.

With regard to long-term cosmetic outcomes, results of both SILS and 3-port appendectomy were outstanding. The majority of patients in both arms of the trial reported near-perfect body image and cosmetic appearance. The 3-port patients reported slightly better physical attractiveness, and the SILS patients reported slightly better scar. We believe these differences are unlikely to be clinically important for the vast majority of patients.

Our study had several limitations. One was its unblinded design. Both patient and treatment team were aware of which arm of the trial the patient was in. Because our goal was to assess incisions visible to the patient, this study design was unavoidable. Also, although the single institution, single-surgeon design of this trial eliminated the confounding effect of multiple surgeons and operating rooms, it might limit the generalization of results to other practice settings. Third, the trial was conducted in

### Table 3. Outcomes after Single-Incision Laparoscopic Surgery or 3-Port Laparoscopic Appendectomy

<table>
<thead>
<tr>
<th>Outcome</th>
<th>SILS patients (n = 37)</th>
<th>3-Port patients (n = 38)</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pain, mean ± SD</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hydromorphone use in first 12 h, mg</td>
<td>3.9 ± 1.3</td>
<td>2.8 ± 1.7</td>
<td>0.01*</td>
</tr>
<tr>
<td>Pain score in first 12 h, 0 to 10</td>
<td>4.4 ± 1.6</td>
<td>3.5 ± 1.5</td>
<td>0.01*</td>
</tr>
<tr>
<td>Duration of opiate after discharge, d</td>
<td>4.0 ± 2.9</td>
<td>3.3 ± 2.5</td>
<td>0.39</td>
</tr>
<tr>
<td><strong>Recovery, mean ± SD</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Length of hospitalization, d</td>
<td>1.4 ± 0.8</td>
<td>1.6 ± 1.8</td>
<td>0.65</td>
</tr>
<tr>
<td>Time off work, d</td>
<td>8.1 ± 6.2</td>
<td>6.9 ± 4.1</td>
<td>0.42</td>
</tr>
<tr>
<td><strong>Complications, n (%)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wound infection</td>
<td>0</td>
<td>0</td>
<td>&gt;0.99</td>
</tr>
<tr>
<td>Deep space infection</td>
<td>1 (3)</td>
<td>0</td>
<td>0.49</td>
</tr>
<tr>
<td>Wound seroma</td>
<td>1 (3)</td>
<td>0</td>
<td>0.49</td>
</tr>
<tr>
<td>Postoperative bleeding</td>
<td>0</td>
<td>1 (3)</td>
<td>&gt;0.99</td>
</tr>
<tr>
<td>Urinary retention</td>
<td>2 (5)</td>
<td>2 (5)</td>
<td>&gt;0.99</td>
</tr>
<tr>
<td>Prolonged postoperative ileus</td>
<td>1 (3)</td>
<td>1 (3)</td>
<td>&gt;0.99</td>
</tr>
<tr>
<td>Readmission within 30 d</td>
<td>2 (5)</td>
<td>1 (3)</td>
<td>0.61</td>
</tr>
<tr>
<td><strong>Body image after 6 mo, mean ± SD</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overall body satisfaction, 4 points max</td>
<td>3.5 ± 1.0</td>
<td>3.7 ± 0.6</td>
<td>0.86</td>
</tr>
<tr>
<td>Damage to body, 4 points max</td>
<td>3.7 ± 0.4</td>
<td>3.8 ± 0.4</td>
<td>0.18</td>
</tr>
<tr>
<td>Physical attractiveness, 4 points max</td>
<td>3.8 ± 0.4</td>
<td>4.0 ± 0.4</td>
<td>0.04*</td>
</tr>
<tr>
<td>Masculinity/femininity, 4 points max</td>
<td>4.0 ± 0.0</td>
<td>4.0 ± 0.2</td>
<td>0.34</td>
</tr>
<tr>
<td>Looking at oneself naked, 4 points max</td>
<td>3.9 ± 0.3</td>
<td>3.9 ± 0.2</td>
<td>0.63</td>
</tr>
<tr>
<td><strong>Cosmetic appearance after 6 mo, mean ± SD</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cosmetic appearance of abdomen, max 20</td>
<td>16.3 ± 3.5</td>
<td>15.4 ± 3.7</td>
<td>0.48</td>
</tr>
<tr>
<td>Cosmetic appearance of scars, max 20</td>
<td>16.5 ± 3.2</td>
<td>14.4 ± 4.1</td>
<td>0.09</td>
</tr>
<tr>
<td>Satisfaction with scars, max 20</td>
<td>18.5 ± 2.2</td>
<td>16.9 ± 3.7</td>
<td>0.25</td>
</tr>
<tr>
<td>Discomfort of scars, max 20</td>
<td>18.6 ± 2.9</td>
<td>18.6 ± 2.4</td>
<td>0.81</td>
</tr>
<tr>
<td>Overall impression of scars, max 20, mean ± SD</td>
<td>18.4 ± 2.7</td>
<td>16.4 ± 3.0</td>
<td>&lt;0.01*</td>
</tr>
</tbody>
</table>

Continuous variables are reported as mean ± SD and were compared using the t-test. Survey results (ordinal variables) were compared using the Mann-Whitney U test. Categorical variables were compared using either Fisher’s exact test or chi-square test.

*Significant.

SILS, single-incision laparoscopic surgery.
CONCLUSIONS
The SILS appendectomy caused more pain and longer operative times than 3-port laparoscopic appendectomy, without improving short-term recovery or complication rate. Long-term body image and cosmetic appearance were excellent in both groups. These results call into question whether SILS can improve patient outcomes when compared with multiport laparoscopy. A recent prospective, multicenter trial of SILS vs 4-port laparoscopic cholecystectomy demonstrated slightly better cosmetic results for SILS patients, but at the expense of 30% longer operative times, a 7-fold increase in the risk of umbilical hernia, and a trend toward more early pain. Our prospective trial similarly showed worse outcomes for SILS patients undergoing appendectomy.

Author Contributions
Study conception and design: Carter, Lin, Rogers, Harris
Acquisition of data: Carter, Kaplan, Nguyen
Analysis and interpretation of data: Carter, Kaplan, Nguyen
Drafting of manuscript: Carter, Kaplan, Lin, Harris
Critical revision: Carter, Lin, Rogers, Harris

Acknowledgment: The authors would like to thank Pamela Derish in the Department of Surgery at University of California, San Francisco for copyediting the manuscript.

REFERENCES


