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Review of single incision laparoscopic surgery in colorectal surgery

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Abstract

As surgical techniques continue to move towards less invasive techniques, single incision laparoscopic

surgery (SILS), a hybrid between traditional multiport laparoscopy and natural orifice transluminal endoscopic surgery, was introduced to further the enhanced outcomes of multiport laparoscopy. The safety and feasibility of SILS for both benign and malignant colorectal disease has been proven. SILS provides the potential for improved cosmesis, postoperative pain, recovery time, and quality of life at the drawback of higher technical skill required. In this article, we review the history, describe the available technology and techniques, and evaluate the benefits and limitations of SILS for colorectal surgery in the published literature.

Key words: Laparoscopic colectomy; Minimally invasive colorectal surgery; Single-incision laparoscopic surgery

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Core tip: As surgical techniques continue to move towards less invasive techniques, single incision laparoscopic surgery (SILS) is a valuable platform with distinct advantages and comparable or better outcomes than other minimally invasive platforms. The safety and feasibility of SILS for both benign and malignant colorectal disease has been proven, and this review of the history, current state, available technology, limitations to widespread use, and their solutions will be a valuable addition to the published literature. It will draw attention to the benefits and potentially increase use of the platform and minimally invasive surgery as a whole.

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INTRODUCTION

Since the first laparoscopic colectomy was described in 1991, minimally invasive colorectal surgery has continued to grow^[1]. The expanding use of laparoscopy has been the greatest technical and clinical advance in the field of colorectal surgery. Laparoscopic colorectal surgery has been proven to improve patient outcomes, including faster return of gastrointestinal function, less postoperative pain, shorter length of stay, lower complication and readmission rates, and lower total healthcare utilization compared to open surgery^[1-14]. Despite proven benefits, use of laparoscopy is estimated at only 50% of all colorectal procedures, 20% of colon cancer, and 10% of rectal cancer procedures in the United States^[15,16]. Thus, there is room to increase utilization and the benefits. In addition, there is the continued drive towards reduced port and "scarless" surgery, and great efforts have been made to minimize surgical trauma, improving cosmesis and surgery-related pain and morbidity. Techniques, such as natural orifice transluminal endoscopic surgery (NOTES) and single-incision laparoscopy surgery (SILS) have been developed to reach the goals. NOTES is still in the experimental stages, but SILS is ready for incorporation into routine practice and currently regarded as the next major advance in the progression of minimally invasive surgical approaches feasible in generalized use^[17,18].

SINGLE INCISION LAPAROSCOPIC SURGERY

SILS was developed to further the outcomes of multiport laparoscopy. The SILS technique was first reported for colorectal surgery in 2008, when both Remzi *et al.*^[19] and Bucher *et al.*^[20] reported use for right colectomy. Since that time, multiple studies have proven SILS is safe and feasible for the full array of benign and malignant colorectal disease, and its applications continue to grow^[21-35]. SILS is currently regarded as the next major advance in the progression of minimally invasive surgical approaches to colorectal disease suitable for generalized use^[17] (Figure 1).

TECHNICAL NOTES

Most SILS procedures enter the peritoneum at the umbilicus, creating a "hidden" incision and allowing the fascial incision to be lengthened without extending the overlying skin incision^[36]. If a stoma is planned, the ostomy site may be used for access, allowing "scarless" surgery^[23,37,38].

For access, there are several commercially produced SILS ports, as well as a homemade glove port. The most common ports are the SILS™ Port (Covidien, Mansfield, Massachusetts, United States), the GelPOINT® platform (Applied Medical, Rancho Santa Margarita,

CA, United States), and the TriPort or QuadPort (Olympus Medical, Center Valley, PA, United States). All devices have three or more working channels in the single port to introduce the laparoscopic instruments and a camera into the operative field through a solitary incision. The single incision helps reduce fascial defects, abdominal wall trauma, and their associated postoperative pain and hernia risk^[39-41]. Each port is introduced through a 2-4 cm skin and fascial incision, and has costs and benefits. The SILS™ Port (Covidien, Mansfield, MA, United States) is pliable elastomeric foam that creates a seal with the skin to maintain pneumoperitoneum, offers enhanced mobility, and allows the surgeon to interchange 5-mm and 12-mm ports. However, the SILS™ port is limited to 3 trocars and has no wound protector for specimen extraction. The GelPOINT® uses a wound protector sleeve inserted into the peritoneum and GelSeal® cap that trocars are inserted into per surgeon preference. The port offers a low internal profile, which may help accommodate various abdominal wall sizes, and the sleeve offers protection during specimen extraction from tumor seeding and superficial wound infections^[42,43]. The GelPOINT® has a larger profile on the abdominal wall, and may lose pneumoperitoneum with extreme torque. The TriPort and QuadPort channels have three or four instrument channels, respectively, a similar to the GelPOINT®, and a lower external profile. However, the assembly, insertion, and extracorporealization are reported more difficult than other platforms. The glove port uses a sterile, non-latex glove secured to a small wound protector, with the glove's fingers used for instrument and camera access. This approach is simple, inexpensive, and easily reproducible, but there is a poor seal and lack of rigidity provided from the finger ports compared to commercially available devices^[35,44-47].

Standard laparoscopic tools are commonly used with SILS, but straight, curved, and articulating instruments are available. Straight instruments offer rigidity, but when working in a parallel, fixed space, there can be collisions between the working ports and the camera. Curved instruments were introduced to remedy collisions, but they cannot be passed through conventional, straight trocars. Articulating instruments were designed to overcome the lack of triangulation, as they articulate at the tip, rotating 360° around the instrument axis. However, there is a loss of rigidity and tactile feedback with the flexible tools^[48-50]. It is generally agreed upon that straight laparoscopic instruments are preferred and the curved or articulating instruments are not required or commonly used in practice.

OUTCOMES WITH SILS

In all clinical and quality metrics, SILS has comparable outcomes to traditional laparoscopy^[34,39]. Studies

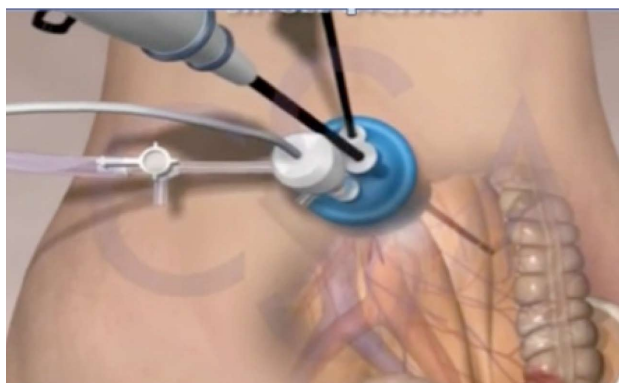


Figure 1 Single incision laparoscopic surgery animation.



Figure 2 Specimen removal through single incision platform.

have proven SILS is feasible and safe for benign and malignant colorectal disease^[22,28-30,32,33]. From early reports, SILS had similar postoperative outcomes, including complication, intraoperative conversion, and readmission rates^[39]. Oncologic outcomes, including the feasibility of R0 resection, specimen length, number of lymph nodes harvested, and proximal and distal margins were comparable to multiport laparoscopy^[51-54]. SILS has been shown safe and feasible specifically in rectal resections^[29]. Initial studies reported an increased operative time with SILS, but failed to take into account the learning curve and need for experience^[52,55]. The operative time decreases with accumulating experience, with a learning curve defined between 30 to 36 cases^[56].

SILS has distinct benefits over traditional laparoscopic surgery. Using a single port with multiple incorporated working channels, SILS has reduced the number of incisions and tissue trauma required for surgery, improved cosmesis, and lowered the rate of port-site related complications and incisional hernias^[39-41,57] (Figure 2). Reduced perioperative pain is another reported advantage of SILS over traditional multiport laparoscopy, with the reduction in pain translating to lower pain scores and opioid use from the immediate post-operative period up to post-operative day 2^[39,41]. SILS has also shown a significantly shorter length of stay (LOS); studies have demonstrated LOS more than 1 d shorter for SILS compared to multiport laparoscopy^[28,39]. A recent meta-analysis reviewing 14 studies comparing SILS to traditional multiport laparoscopy concluded SILS had lower blood loss, decreased blood transfusion requirement, shorter time to flatus, shorter hospital stay, and smaller incision^[51].

TECHNICAL CHALLENGES

The use of SILS introduced several new technical challenges, which may limit widespread use of the platform^[58]. The ergonomic and technical requirements of SILS are distinct from those used in conventional multiport laparoscopy, initially adding difficulty even for experienced laparoscopic surgeons^[59,60]. The

technical challenges are further amplified in colorectal procedures, where there is the need to work in more than one quadrant^[58,61]. First, there is the challenge from the in-line orientation of the working trocars through the single access port causes the visual axis to become more in-line, with camera movement resulting in inadvertent movement of the adjacent instrument^[17,62]. Working through a small single incision with multiple parallel, instruments competing for the same space at the fulcrum of the entry port decreases the range of motion and external working space, increasing instrument collisions^[28,58,63]. These collisions are experienced both intra-corporeally, creating difficulty maintaining pneumoperitoneum, and extra-corporeally, complicating the role of the assistant holding the camera^[28]. This forces the surgeon to operate with crossed hands to acclimate^[17,62]. The proximity of the trocars at a fixed position, restricted freedom, and clashing of the instruments is contradictory to the traditional teaching of triangulation in laparoscopy^[64]. These problems in exposure and "crowding" add to the difficulty in the SILS technique and can result in restricted visualization, inadequate dissection and mobilization, and the potential for inadvertent injury^[55,65].

With increasing operator experience, these ergonomic and technical challenges can be readily overcome. Technical instruments and procedural adaptations have been developed to help work through these challenges. To improve surgeon efficiency and decrease collisions, it has also been recommended to keep the laparoscope away from the surgeon's hands, such as with a flexible-tipped or bariatric-length laparoscope^[24,28,66,67]. Articulating or curved instruments can be used to help recreate triangulation familiar with multiport laparoscopy^[58]. For assistance in pelvic and multi-quadrant cases, a SILS +1 technique has been developed and validated^[65]. With SILS +1, the single access device is introduced through a Pfannenstiel incision and an additional 5-mm port is placed through the umbilicus for the laparoscopic camera, allowing access to more than one abdominal quadrant and minimizing "sword fighting" between the surgeon

and the camera holder^[65]. To become proficient at SILS, one idea is to become proficient at reduced port laparoscopy - using 3 ports; then the transition to SILS will be more natural.

CURRENT STATE AND MOVING FORWARD WITH SILS

Despite evidence supporting the use and proven benefits, SILS has not been widely adopted. The main reason cited is the ergonomic demands and additional time, costs, and skills required, especially in early cases^[55,59,64,68]. Surgeon experience can overcome the technical and ergonomic challenges, and specialized instruments and platforms have been developed to help ascend the learning curve^[17,62].

The technology was also advocated for surgeons experienced with laparoscopy and minimally invasive techniques, and results described in the published literature are achieved by skilled laparoscopic surgeons beyond the learning curve performing the procedures^[32,34,69,70]. In addition, published experience has centered on non-obese patients^[23,66,70-74]. To increase utilization of this minimally invasive technique, its feasibility in different patient populations must be explored^[72]. The learning curve to achieve competence with this technology has been defined, and there are no increased complications or negative outcomes reported during the early phases of the learning curve^[56,72]. Therefore, increasing use of SILS for patient benefits and increased overall use of minimally invasive colorectal surgery is encouraged.

CONCLUSION

As the field of colorectal surgery has emphasized moving towards less invasive techniques, single incision laparoscopic surgery, a hybrid between traditional multiport laparoscopy and NOTES, is the natural evolution in minimally invasive surgery. SILS offers distinct benefits over traditional multiport laparoscopy, but widespread use has been limited from technical, ergonomic, and patient selection challenges. With experience demonstrating the safety and feasibility, and the learning curve for competence defined, increased use of SILS in colorectal surgery is encouraged.

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