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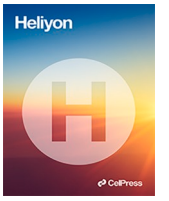

Comparative analysis of transvaginal natural orifice transluminal endoscopic surgery versus laparoendoscopic single-site sacrocolpopexy for pelvic organ prolapse: A propensity score matching study

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ABSTRACT

Purpose: To compare the safety, feasibility, and effectiveness of transvaginal natural orifice transluminal endoscopic sacrocolpopexy (vNOTES-SC) and laparoendoscopic single-site sacrocolpopexy (LESS-SC) for pelvic organ prolapse (POP).

Method: Ninety-four patients with POP who underwent vNOTES-SC or LESS-SC from October 2016 to November 2018 were included. The propensity score matching method was used for 1:1 matching between the two surgery groups. After matching, the general perioperative indicators, surgical complications, and the subjective and objective therapeutic effects of the two groups 3 years post-surgery were analyzed.

Results: After matching, 36 patients in each group were included, exhibiting balanced and comparable baseline data and an average follow-up of 48.6 ± 7.44 months. The operation time and postoperative hospitalization days were significantly reduced in the vNOTES-SC group ($P < 0.05$). However, perioperative complication incidence was not significantly different between the two groups ($P > 0.05$). Additionally, no significant differences were detected in de novo stress urinary incontinence (16.7% vs. 13.9%), de novo overactive bladder (de novo OAB, 8.3% vs. 0.0%), urination disorder (2.8% vs. 0.0%), defecation disorder (0.0% vs. 2.8%), lumbosacral pain (0.0% vs. 2.8%), or mesh complication (2.8% vs. 5.6%) incidences between the vNOTES-SC and LESS-SC groups ($P > 0.05$). Prolapse recurrence was not reported in either group. The quantitative description of pelvic organ position (POP-Q), Pelvic Floor Impact Questionnaire-7 (PFIQ-7), and Patient Global Impression of Improvement scale (PGI-I) scores showed improvement after the operation, but no significant differences were observed between the two groups ($P > 0.05$).

Conclusion: The 3-year follow-up revealed that vNOTES-SC and LESS-SC had similar complications and efficacy rates. Compared with LESS-SC, vNOTES-SC resulted in shorter operation time and fewer postoperative hospitalization days (corresponding to the enhanced recovery after surgery [ERAS] concept), along with better cosmetic results without a scar. Therefore, our study

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findings suggest that clinicians should choose the surgery method based on the specific situation, and we recommend choosing vNOTES-SC when both surgeries are suitable.

1. Background

Pelvic organ prolapse (POP) refers to the positional and functional abnormality of one or more pelvic organs caused by the weakness or defect of the pelvic floor that supports the tissues. A multicenter cross-sectional study [1] showed that symptomatic POP was prevalent in 9.6% of adult females in China. Moreover, Wu et al. [2] reported that symptomatic POP prevalence among American women will increase by 46% from 2010 to 2050, reaching 5 million by 2050. Further, this condition can seriously affect the physical and mental health of women.

According to the three compartments concept, POP can be categorized as anterior, middle, and posterior pelvic prolapse, with symptomatic stage IV POP mainly involving the middle pelvic cavity. Sacrocolpopexy is considered the gold standard for treating middle pelvic prolapse. Sacral hysteropexy was first reported as early as 1957 by Arthure et al. [3], while Nezhat et al. [4] published the first case of laparoscopic sacrocolpopexy (LSC) in 1994. Subsequently, surgical routes for sacrocolpopexy have diversified with the rapid development and extensive application of minimally invasive techniques, including LSC with or without robot assistance, transvaginal natural orifice transluminal endoscopic sacrocolpopexy (vNOTES-SC) [5], and laparoendoscopic single-site sacrocolpopexy (LESS-SC) [6]. Currently, only a few studies have investigated the clinical application and efficacy of vNOTES-SC and LESS-SC. Furthermore, most research includes short-term follow-up studies. Thus, the medium- and long-term efficacies of these two surgeries require further evaluation. Additionally, research directly comparing vNOTES-SC and LESS-SC is lacking, leading to an unclear understanding of the differences between the safety, feasibility, and effectiveness of these two surgeries. Therefore, this study aimed to compare and analyze the perioperative safety, mid-term efficacy, and complications of vNOTES-SC and LESS-SC in POP treatment, as well as to explore the safety, feasibility, and effectiveness of these two surgical approaches and provide crucial reference information for clinical decision-making.

2. Materials and methods

2.1. General information

A total of 94 patients with POP who underwent vNOTES-SC or LESS-SC at the Third Affiliated Hospital of Guangzhou Medical University from October 2016 to November 2018 were included. Patient inclusion criteria were as follows: (1) a II–IV degree of mainly uterine or vault prolapse with or without anterior and posterior vaginal prolapse according to the pelvic organ prolapse quantification system (POP-Q), (2) surgical treatment indicated due to unsatisfactory conservative treatment effect or inability to use a pessary, (3) surgery can be tolerated, (4) completed her family so without requirement for preserving the uterus. Patient exclusion criteria were as follows: (1) acute inflammation of reproductive or urinary systems, (2) a history of rectal endometriosis or severe pelvic adhesion, (3)

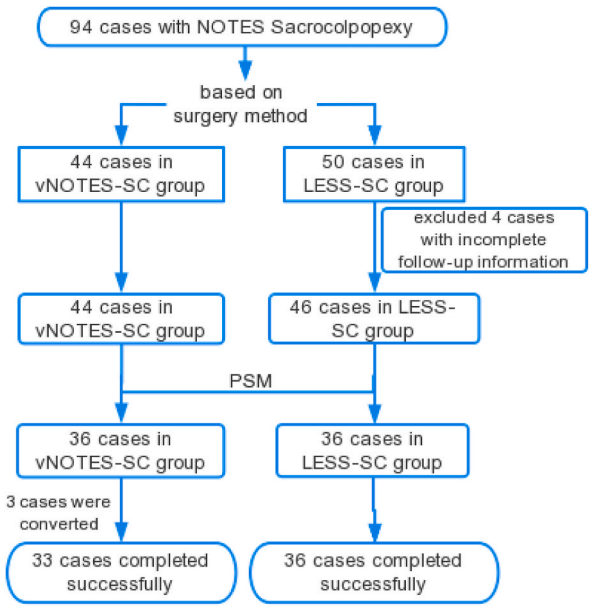

Fig. 1. Research flow chart.

gynecological malignant tumor; (4) cardiopulmonary diseases that make operation intolerable; (5) combined neuropsychiatric disorders leading to uncooperative behavior; or (6) a history of mesh allergy.

After evaluating the patient's condition, the patient was informed of the optional surgical methods and their potential benefits and risks. The patient then chose the surgical method and signed an informed consent form. According to the surgical route chosen, the patients were classified into the vNOTES-SC (n = 44) and LESS-SC groups (n = 50) (Fig. 1).

2.2. Surgical methods

The patients in both groups were operated on by the same surgeon, minimizing the bias associated with intrapersonal surgical proficiency and institution. The main surgical procedures and operating points in the two surgery groups are described as follows.

vNOTES-SC group: I. After transvaginal hysterectomy, points Aa and Ba were marked. Next, 1:1000 diluted epinephrine saline was injected into the anterior vaginal wall to form a water pad, which was then separated from the vaginal stump to point Aa. A similar procedure was performed for the posterior vaginal wall. II. The lengths of the anterior and posterior vaginal walls and the total vagina length were determined. III. The anterior and posterior vaginal wall meshes were then trimmed and fixed by sutures. IV. After mesh fixation, the endoscope working channel was established in the natural vaginal canal. V. Using this channel, the presacral region was separated, exposing the sacral promontory, the pelvic surface of the S1 vertebral body, and the anterior longitudinal ligament. VI. Next, a retroperitoneal tunnel was created between the right side of the rectum and the right ureter by separating the peritoneal space from the medial aspect of the uterosacral ligament to the presacral region. VII. Furthermore, the distance from the anterior longitudinal ligament to the hymen was measured to ensure a tension-free mesh by trimming and threading the long arm of the Y-shaped mesh through the retroperitoneal tunnel. The Y-shaped mesh was further fixed to the anterior longitudinal ligament with two stitches using a Johnson & Johnson w6977 suture. VIII. Finally, the mesh was completely peritonealized by peritoneum closure via suturing, followed by the suturing of the anterior and posterior vaginal walls.

LESS-SC group: I. In this procedure, the transumbilical single-port laparoscopic working channel was first established. II. Next, hysterectomy was performed using conventional techniques, along with the separation of the vesicovaginal and rectovaginal spaces downward. III. The pelvic surface and anterior longitudinal ligament of the S1 vertebral body were then separated and exposed, establishing a retroperitoneal tunnel from the right sacral ligament to the vaginal stump. IV. Further, the meshes were trimmed, and the anterior and posterior vaginal wall meshes were spread in parallel and fixed to the fibromuscular layers of the corresponding vaginal walls via intermittent suturing. Then continuous sutured the vaginal stump. V. Additionally, the vaginal stump was lifted, and the mesh length and tension were adjusted, followed by mesh fixation to the anterior longitudinal ligament via two stitches using a Johnson & Johnson w6977 suture. VI. Lastly, the peritoneum was closed to ensure mesh peritonealization.

2.3. Postoperative management and follow-up

The vaginal gauze was removed 48 h after surgery. In addition, the urinary catheter was removed 72 h post-surgery, and the residual urine volume of the bladder was measured. Antibiotics were routinely used 48 h after surgery to prevent infections associated with mesh implantation. Follow-up and registration were performed 1 month, 3 months, 6 months, and 1 year postoperatively, and subsequent annual follow-up was conducted at the outpatient clinic or via telephone. The follow-up process included administering the physical examination, the POP-Q scores, and questionnaires. Statistical analysis was performed using the last follow-up results. The statistical follow-up deadline was December 2021.

2.4. Observation indexes

Perioperative related indexes: Operation time (in min), intraoperative bleeding volume (in ml); preoperative and postoperative hemoglobin change (in g/L); rate of change in surgery approach (in %); postoperative first flatus time (in h); residual urine volume (in ml); postoperative hospitalization days, including operation day and discharge day (in days); and hospitalization expenses (in CNY) were estimated.

Perioperative and mid-term follow-up complications: The incidence (%) of injury to adjacent organs and massive hemorrhage (>500 ml [7–9]) during the operation was measured. Perioperative complication incidence (%) included postoperative fever, intestinal obstruction, and urinary retention (>150 ml) [10]. The frequency of mesh exposure and infection after operation (described according to the Category-Time-Site classification) [11], de novo stress urinary incontinence (de novo SUI), de novo overactive bladder (de novo OAB), urination or defecation disorder, lumbosacral pain, and incision infection or hernia in the vNOTES-SC and LESS-SC groups were also recorded. The Clavien–Dindo classification [12] was used to evaluate the severity of the surgical complications in the two groups.

Clinical efficacy: Objective efficacy was evaluated according to the postoperative POP-Q score. Relapse was defined as [13] symptomatic POP-Q stage II or POP-Q stage $\geq$ III. Subjective efficacy was determined using the Pelvic Floor Impact Questionnaire-7 (PFIQ-7) and the Patient Global Impression of Improvement scale (PGI-I) to understand the improvement of pelvic organ function and quality of life in the two groups. The PGI-I also reflected the subjective satisfaction of the patients, wherein their subjective satisfaction was rated as "significantly improvement," "improvement trend," or "slightly better than pre-surgery" based on their PGI-I score.

2.5. Statistical methods

The patients in the vNOTES-SC and LESS-SC groups were matched using the propensity score matching (PSM) function in SPSS 25.0 software. Variables that exhibited a significance level of $P < 0.01$ in the baseline data analysis as well as those that showed potential clinical significance based on the previous literature results were selected as covariates and included in the logistic regression model. The corresponding propensity score was then calculated. Using a caliper value of 0.2, 1:1 matching was performed for individuals with similar scores. Quantitative data with normal distribution were expressed as mean ± standard deviation ($\bar{x} \pm s$) and assessed using the T test. Additionally, data exhibiting non-normal distribution were represented as interquartile range (M [P25, P75]) and analyzed via the nonparametric rank-sum test. Count data were denoted as rate and constituent ratio (%) and examined using Pearson's chi-square test. Finally, semi-quantitative data was evaluated using the Mann–Whitney rank-sum test. Using the Cumulative Sum (CUSUM) analysis method to analyze the learning curve. Statistical analyses were conducted using SPSS 25.0 software. $P < 0.05$ was considered statistically significant.

3. Results

3.1. Comparison of the baseline data between the two groups before PSM

Among the 94 patients, four in the LESS-SC group were excluded due to incomplete follow-up information; thus, the remaining 90 patients were included in the statistical analyses. Of the remaining 90 patients, 44 were in the vNOTES-SC group and 46 in the LESS-SC group. Our baseline analysis results revealed significant differences between the vNOTES-SC and LESS-SC groups in the incidence of previous pelvic surgery (25.0% vs. 45.7%, $P < 0.05$; including lower abdominal surgery, such as uterus, fallopian tube, ovary surgery, and appendectomy surgery) and preoperative PFIQ-7 scores (140.04 ± 39.73 vs. 112.73 ± 29.78; $P < 0.05$).

3.2. Comparison of the baseline data between the two groups after PSM

PSM detected 36 matching pairs (72 patients), i.e., 36 patients each in the vNOTES-SC and LESS-SC groups. Therein, one patient in the vNOTES-SC group relapsed after laparoscopic suspension of the uterosacral and round ligaments, while one in the LESS-SC group relapsed after the Manchester operation. Moreover, no significant differences were observed in the baseline data between the two groups after PSM ($P > 0.05$), indicating that these pairs were comparable. See Table 1 for more information.

3.3. Comparison of the perioperative results between the vNOTES-SC and LESS-SC groups

In the vNOTES-SC group, three patients (8.3%) required alteration in their surgery route due to inaccurate preoperative evaluation and severe pelvic adhesion during the operation. Nevertheless, vNOTES-SC was completed successfully in the remaining 33 patients. All 36 patients in the LESS-SC group completed the surgery successfully, with no cases of changed surgical approach. The observation indexes of blood loss, hemoglobin change, postoperative exhaust time, residual urine volume, and hospitalization expenses were not significantly different between the two groups ($P > 0.05$). However, operation time and postoperative hospitalization days in the vNOTES-SC group were significantly reduced compared to those in the LESS-SC group (operation time: 190.14 ± 47.01 min vs. 233.75 ± 50.86 min; postoperative hospitalization days: 6 [5.25, 7] days vs. 7 [7, 8] days; $P < 0.05$ for both). See Table 2 for all results. Using CUSUM analysis method to analyze the learning curve found the operating time to decline sharply following the first 10 cases in two groups, more obvious in vNOTES-SC group (Fig. 2).

Table 1
Comparison of the baseline data between the vNOTES-SC and LESS-SC groups after PSM.

Baseline characteristics	vNOTES-SC(n = 36)	LESS-SC(n = 36)	P
Age (in years)	59.83 ± 8.38	60.42 ± 8.91	0.776
BMI (in kg/m^2)	22.98 ± 2.69	23.31 ± 3.00	0.628
gravidity	3(2, 4.75)	3(2, 4.75)	0.913
parity	2(1, 3)	2(1, 3)	0.671
Menopausal years (in years)	9.5(4, 14.5)	10(5.5, 12.75)	0.572
Comorbidities (in %)	10(27.8)	12(33.3)	0.609
Previous pelvic surgery (in %)	11(30.6)	12(33.3)	0.800
PFIQ-7	132.41 ± 38.77	119.31 ± 29.33	0.111
Maximum index of POP (in %)			
II	1(2.8)	0(0.0)	
III	27(75.0)	30(83.3)	0.486
IV	8(22.2)	6(16.7)	

Table 2
Comparison of the perioperative results between the vNOTES-SC and LESS-SC groups.

Variables	vNOTES-SC(n = 36)	LESS-SC(n = 36)	P
operation time (in min)	190.14 ± 47.01	233.75 ± 50.86	<0.001
blood loss (in ml)	20(20, 50)	20(20, 30)	0.793
hemoglobin change (in g/L)	11.5(8, 18)	13(5, 18.75)	0.632
first flatus time (in h)	40.5(26.25, 45.75)	43(28.5, 46)	0.410
residual urine volume (in ml)	3.5(0, 15.75)	5.5(0.5, 28)	0.166
postoperative hospitalization days (in days)	6(5.25, 7)	7(7, 8)	<0.001
hospitalization expenses (in CNY)	45931.28 ± 7948.11	46273.40 ± 4187.9	0.820
conversion rate (in %)	3(8.3)	0(0.0)	0.238

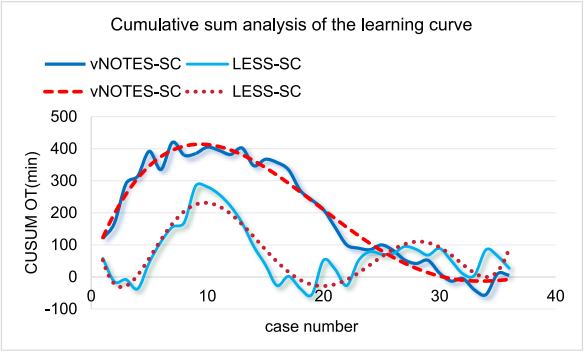

Fig. 2. Using the CUSUM analysis method to analyze the learning curve for vNOTES-SC and LESS-SC. CUSUM OT, Cumulative sum of operation time.

3.4. Comparison of the surgical complications between the two groups

No injury to the adjacent organs (such as the bladder and ureter) or complications (including massive hemorrhage or hematoma) were reported during the operation. Additionally, no complications were observed in the vNOTES-SC group during postoperative hospitalization. In contrast, postoperative fever and incomplete intestinal obstruction were found in three patients (8.3%) and one patient (2.8%), respectively, in the LESS-SC group on the third day after surgery. In addition, perioperative complication incidence was not significantly different between the two groups ($P > 0.05$). See Table 3 for complete details.

Patients in the vNOTES-SC and LESS-SC groups were followed up for at least 3 years, with an average follow-up of 48.65 ± 7.44 months. No incision-related complications were observed in the two groups. In the vNOTES-SC group, six patients (16.7%) experienced de novo SUI, with none requiring surgical treatment. One patient (2.8%) had a urination disorder, presenting with dysuria and prolonged urination duration. Although the pre-existing OAB symptoms of four patients were effectively alleviated after the operation, three patients (8.3%) exhibited de novo OAB. Furthermore, one patient (2.8%) was found to have vaginal mesh exposure (2 × 1 cm, CTS code: 3BaT4S1) on a return visit 2 years postoperation and was treated with surgery. In the case of the LESS-SC group, five patients (13.9%) developed de novo SUI postoperatively. Among them, one patient underwent surgery for SUI 9 months after the initial

Table 3
Comparison of the surgical complications between the vNOTES-SC and LESS-SC groups.

Variables	vNOTES-SC(n = 36)	LESS-SC(n = 36)	P
Perioperative complications (in %)			
Postoperative fever	0(0.0)	3(8.3)	0.238
intestinal obstruction	0(0.0)	1(2.8)	1.000
Mid-term follow-up complications (in %)			
De novo SUI	6(16.7)	5(13.9)	0.743
De novo OAB	3(8.3)	0(0.0)	0.238
urination disorder	1(2.8)	0(0.0)	1.000
Defecation disorder	0(0.0)	1(2.8)	1.000
lumbosacral pain	0(0.0)	1(2.8)	1.000
Mesh complications	1(2.8)	2(5.6)	1.000
Clavien-Dindo classification			
I	10(27.8)	8(22.2)	0.586
II	0(0.0)	4(11.1)	0.123
IIIb	1(2.8)	1(2.8)	1.000
IIIa/IV/V	0(0.0)	0(0.0)	–

surgery. The pre-existing OAB symptoms of six patients were effectively alleviated postoperation, with no incidence of de novo OAB. Additionally, one patient (2.8%) had long-term constipation and defecation disorder after the operation, which improved after receiving medication to relieve constipation. Moreover, one patient (2.8%) reported occasional lumbosacral pain since 1 year after the operation. Lastly, two patients (5.6%) were successfully treated with estrogen cream after mesh exposure in the vaginal stump (CTS code: 2BaT3S1, 2BaT3S1) was detected on their return visit 3 months after the operation. Further, no significant differences were found in the complication incidence between the two groups (all $P > 0.05$) during the mid-term follow-up. See Table 3 for all information.

Additionally, the Clavien–Dindo classification was employed to grade the perioperative and mid-term follow-up complications of the vNOTES-SC and LESS-SC groups. The results showed that the most serious complications in the two groups were grade IIIb complications (only one case in each group), with no grade IV or V complications in both groups. Furthermore, no significant differences were found in the complications between the two groups at all grade levels ($P > 0.05$). See Table 3 for more details.

3.5. Comparison of the clinical efficacy between the two groups

At 3 years after surgery, the vNOTES-SC and LESS-SC groups retained satisfactory anatomical positions. Moreover, the measures of the indicator points of the postoperative POP-Q were significantly improved when compared with those before surgery ($P < 0.05$). In addition, no significant difference was observed in the postoperative POP-Q indicator points between the two groups ($P > 0.05$). Further, no recurrence or reoperation for prolapse was reported in the patients of the two groups.

The PGI-I scores indicated that the postoperative general conditions of the vNOTES-SC and LESS-SC groups were improved. Specifically, "significant improvement" was demonstrated in 97.2% of the patients in the vNOTES-SC group, whereas an "improvement trend" was noted in 2.8%. In the case of the vNOTES-SC group, the postoperative PGI-I score suggested "significant improvement" in 100% of the patients. The subjective satisfaction rates of the two groups were 100%, with no significant difference between the groups ($P > 0.05$). Lastly, the PFIQ-7 scores after surgery were significantly lower than the preoperative scores in the two groups, exhibiting no significant difference between the two groups ($P > 0.05$).

4. Discussion

Recent development in the NOTES technology has led to a gradual increase in the articles on vNOTES-SC and LESS-SC application for POP treatment [14–17]. However, based on our literature review, our study is the first to compare vNOTES-SC and LESS-SC surgeries with a follow-up of 3 years or more.

In this study, the average follow-up period was 48.65 ± 7.44 months. The incidence of de novo SUI after surgery was not significantly different between the vNOTES-SC and LESS-SC groups (16.7% vs. 13.9%), while the rates in both groups were lower than the incidence rate of 20.6% previously reported in a 3-year follow-up study on LSC surgery [18]. In terms of OAB, previous studies [19, 20] have suggested that pre-existing OAB may resolve postoperatively or patients may develop de novo OAB post-surgery. In our study, surgical treatment effectively relieved OAB in patients with POP, but three (8.3%) exhibited de novo OAB. Thus, pre-existing OAB and de novo OAB in prolapse surgery remain a challenge. In relation to intestinal function, postoperative constipation incidence was similar in the vNOTES-SC and LESS-SC groups, both of which were lower than the reported constipation incidence of 5% after LSC [21, 22].

With regard to the controversy over mesh implantation via the vagina, vNOTES-SC uses a Pure NOTES technique involving the suturing and fixing of the mesh via the vaginal working channel. Furthermore, in our study, numerous measures, such as preoperative evaluation and vaginal preparation [23], strict aseptic procedures, and consideration of the vaginal wall thickness [17] and peritoneal integrity, along with ensuring a tension-free mesh status and postoperative infection prevention were undertaken, leading to only a few mesh-related complications in the vNOTES-SC group. Moreover, no significant difference in mesh complication incidence was observed between the vNOTES-SC group (mesh implantation via the vagina) and the LESS-SC group (mesh placement via the abdomen [transumbilical]). Additionally, vNOTES-SC and LESS-SC did not lead to an increased incidence of mesh complications compared with that caused by abdominal sacrocolpopexy (ASC) 2 years postoperation (7%) [24] and LSC/robotic sacrocolpopexy (0%–9.1%) [25]. In addition, no serious complications, such as sacral osteomyelitis or abscess, occurred in the two groups.

Further, complications in the two groups were resolved using conservative treatments, drugs, or surgical treatments, with no incidence of life-threatening events. Moreover, patients in neither group exhibited major postoperative complications (grade IV/V) according to the Clavien–Dindo classification. Considering these results, the vNOTES-SC and LESS-SC approaches have similar safety outcomes.

In our previous research, we reported that vNOTES-SC [5,26] and LESS-SC [6] had good short-term clinical efficacy after the operation; however, data analysis and comparison of the differences between the two techniques were not performed. Thus, further observation of the mid- and long-term follow-up outcomes was required. In our current study, the mid-term follow-up results of the two groups demonstrated that each indicator point of the POP-Q in the two groups reflected a satisfactory anatomical position 3 years postoperation, with no incidence of prolapse recurrence. According to prior research [27], 90% of the patients with POP indicated that their condition had improved, while 72% reported substantial improvement in their quality of life during the follow-up period of 2 years after surgical treatment. Correspondingly, the PGI-I and PFIQ-7 scores in the current study showed improvement 3 years after surgery in the patients of the two groups when compared with their scores before surgery, indicating that both surgical approaches effectively improved the patient's condition and quality of life. Thus, considering that the mid-term efficacy of the two procedures was comparable, vNOTES-SC and LESS-SC are effective alternative interventions for treating patients with POP.

Although the mid-term follow-up results indicated that the two groups had similar complications and efficacy rates, attention should be given to the fact that three patients in the early stage in the vNOTES-SC group had their surgery route altered due to severe pelvic adhesion. This observation underscores the importance of excluding patients with severe pelvic adhesion and a strict understanding of the indications for the clinical application of vNOTES-SC [28], consistent with the views expressed in the previous literature. Our study also revealed that the vNOTES-SC group had certain advantages in terms of operation time, postoperative hospitalization days, and cosmetic effects. In the case of operation time, using the CUSUM analysis found the operating time to decline sharply following the first 10 cases both groups, but more obvious in vNOTES-SC group. Finally, the vNOTES-SC group exhibited a significantly shorter time than the LESS-SC group. This finding could be because vNOTES-SC effectively utilized the advantages conferred by vaginal surgery, significantly shortening the operation time of vNOTES-SC through vaginal hysterectomy [29]. Moreover, the vaginal incision via vNOTES-SC is longer than the umbilical incision in LESS-SC, while the external pelvic part of the instrument in vNOTES-SC is longer than the internal pelvic part [30]. These features increase the range of motion of the instrument and relatively reduce the chopsticks effect compared with LESS-SC [31]. vNOTES-SC also decreases the time spent on skin incisions and sutures. In relation to the postoperative hospitalization days, the vNOTES-SC group was associated with significantly fewer days than the LESS-SC group. This finding indicates that the overall postoperative rehabilitation speed in the vNOTES-SC group was faster, adhering to the concept of enhanced recovery after surgery (ERAS). Lastly, with regard to the cosmetic benefits, vNOTES-SC used the vagina as the surgery route and avoided any incision on the body surface, thus contributing to the aesthetic effect of vNOTES-SC.

5. Conclusion

In this study, patients who underwent vNOTES-SC or LESS-SC were followed up for at least 3 years, and the follow-up results indicated no significant differences in the complications and efficacy rates between the two surgical approaches. In particular, mesh placement via the vagina in vNOTES-SC did not increase the incidence of mesh complications compared with that via the abdomen in LESS-SC. Furthermore, vNOTES-SC did not involve any incision on the body surface, making it better suited to the aesthetic needs of the female patients. Additionally, the operation time and postoperative hospitalization days of vNOTES-SC were reduced. This reduction in these two perioperative parameters aligns with the ERAS concept, further contributing to the social and economic benefits of medical institutions. In the clinical setting, decisions should be made based on the patient's condition and choice, the surgeon's experience, and available hospital equipment. In the cases where both surgical treatments are applicable, we recommend choosing vNOTES-SC.

6. Research limitation and prospect

This study was a single-center analysis with a relatively small sample size. Thus, considering the lack of a multicenter perspective and large sample data for analysis, our study results might not be extrapolated to all studies of this type. Although the patients in the two study groups were in the early stages, introducing LESS-SC earlier than vNOTES-SC in our hospital might have influenced the study results due to the learning curve associated with the NOTES procedure. Finally, considering that NOTES-SC is an emerging technology, the long-term safety and efficacy of this sacrocolpopexy technique requires further evaluation with longer follow-up data. Future studies should directly compare vNOTES-SC and LESS-SC with the commonly used LSC approach, as well as conduct prospective, long-term, and large-sample research comparing vNOTES-SC with LESS-SC.

Ethics declarations and funding

This study was reviewed and approved by the Ethics Committee of the Third Affiliated Hospital of Guangzhou Medical University, with the approval number: 2020 No. 056. Informed consent was obtained from all the patients. We appreciate the funding from the Guangzhou Municipal Science and Technology Bureau Project of Guangdong, China (grant no. 202102010004), and the Open Project Program of Guangdong Provincial Key Laboratory of Major Obstetric Diseases.

Author contribution statement

Yan Chen: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Youjun Zhou: Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data.

Liping Tan; Shihui Chen: Performed the experiments; Contributed reagents, materials, analysis tools or data.

Chunhua Wu: Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data.

Yanling Liang: Contributed reagents, materials, analysis tools or data.

Nannan Sun: Analyzed and interpreted the data; Wrote the paper.

Juan Liu: Conceived and designed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Data availability statement

Data included in article/supplementary material/referenced in article.

Declaration of interest's statement

The authors declare no conflict of interest.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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