Research Square

Preprints are preliminary reports that have not undergone peer review.
They should not be considered conclusive, used to inform clinical practice,
or referenced by the media as validated information.

Retrospective Comparative Study of Transvaginal Natural Orifice Transluminal Endoscopic Surgery and Vaginal Sacrospinous Ligament Fixation for Pelvic Organ Prolapse

Lulu Liang
Inner Mongolia Medical University
Yingguang Ao
Inner Mongolia Medical University
Jie Liu
Baotou Medical College
Ye Tian
Inner Mongolia Medical University
Xuwen Zhang
Baotou Medical College
Yilin Wang
blueangel12140163.com

Inner Mongolia People's Hospital

Research Article

Keywords: Transvaginal natural orifice endoscopic surgery, sacrospinous ligament fixation, pelvic organ prolapse, POP-Q staging, propensity score matching

Posted Date: July 31st, 2026

DOI: https://doi.org/10.21203/rs.3.rs-10242576/v1

License: This work is licensed under a Creative Commons Attribution 4.0 International License. Read Full License

Additional Declarations: No competing interests reported.

Version of Record: A version of this preprint was published at BMC Women's Health on September 4th, 2026. See the published version at https://doi.org/10.1186/s12905-026-04838-9.

Abstract

Objective

A retrospective analysis was performed to evaluate the clinical efficacy, perioperative indicators and safety of transvaginal natural orifice transluminal endoscopic sacrospinous ligament fixation compared to vaginal sacrospinous ligament fixation in the treatment of pelvic organ prolapse. This study aims to provide a reference for the selection of clinical treatment strategies.

Methods

A retrospective analysis was conducted on 20 patients (experimental group) who underwent transvaginal natural orifice transluminal endoscopic sacrospinous ligament fixation and 100 patients (control group) who underwent vaginal sacrospinous ligament fixation in the People's Hospital of Inner Mongolia Autonomous Region from July 2023 to December 2025. Taking age, BMI, etc. as covariates, propensity score matching was conducted at a ratio of 1:4. Eventually, 20 cases in the experimental group and 80 cases in the control group were included in the analysis. Compare the baseline data before and after matching, perioperative indicators, complications, and postoperative anatomical and functional scores, etc.

Results

Prior to matching, the two groups differed in terms of age and parity. ($P < 0.05$). There was no difference in the baseline data after matching ($P > 0.05$). The experimental group had less intraoperative blood loss, less postoperative pain, shorter hospital stay ($P < 0.05$), and slightly longer operation time ($P < 0.05$). The C point in the experimental group improved significantly compared with the control group 6 months after the operation ($P < 0.05$), and the improvements of PFDI-20, PFIQ-7 and PGI-I in both groups were comparable 6 months after the operation ($P > 0.05$). The incidence of pelvic pain and total complications in the experimental group was lower than that in the control group, and the difference was statistically significant ($P < 0.05$), with good safety.

Conclusion

Transvaginal natural orifice transluminal endoscopic sacrospinous ligament fixation for pelvic organ prolapse has advantages such as less intraoperative bleeding, faster postoperative recovery, lower complication rate, and better recovery of pelvic floor function compared with vaginal sacrospinous ligament fixation. Although the operation time may vary, the overall efficacy is definite and the safety is high. It can be used as one of the preferred surgical methods for the clinical treatment of POP.

1. Introduction

1.1 Research Background

Pelvic Organ Prolapse (POP) is a prevalent pelvic floor dysfunction in gynecology. This condition primarily arises from the relaxation and damage of the supporting tissues of the pelvic floor, leading to the descent of pelvic organs, such as the uterus and vaginal wall, beyond the vaginal opening. The onset of POP is associated with multiple factors, including age, delivery-related injuries, decreased estrogen levels following menopause, chronic cough, and constipation[1]. Epidemiological studies indicate that as the population ages, the incidence of POP among middle-aged and elderly women continues to rise annually[2]. This condition not only significantly impacts patients' physical health but also adversely affects their psychological well-being and overall quality of life. Mild prolapse may result in sensations of heaviness in the lower abdomen

and discomfort in the lumbosacral region. In contrast, moderate to severe prolapse can lead to more pronounced symptoms, such as the protrusion of a mass at the vaginal opening, difficulties with urination, frequent and urgent urination, and abnormal defecation. Additionally, some patients may experience negative emotions, including low self-esteem and anxiety, which can further disrupt their marital relationships. Consequently, POP imposes a considerable burden on both the affected individuals and their families, as well as on society at large[3, 4].

1.2 Current Treatment Status

The treatment plan for pelvic organ prolapse should be meticulously developed, taking into account the patient's age, the degree of prolapse, the severity of symptoms, and fertility considerations. Treatment options are primarily divided into two categories: conservative and surgical. For patients with mild prolapse, minimal symptoms, or fertility concerns, conservative approaches such as pelvic floor muscle exercises, uterine support, and hormone replacement therapy are commonly employed to alleviate symptoms. However, these methods do not address the underlying issue of pelvic floor supporting tissue relaxation. For patients with moderate to severe pelvic organ prolapse (POP-Q stage III and above), significant symptoms, and lack of response to conservative treatment, surgical intervention is currently the most critical and effective treatment option. The primary objective of surgical treatment is to repair the pelvic floor supporting structure, restore the normal anatomical position of pelvic organs, and alleviate clinical symptoms. Sacrospinous ligament fixation, a well-established surgical technique for treating pelvic prolapse, has gained widespread acceptance in clinical practice due to its efficacy in securely anchoring the vaginal apex, reconstructing pelvic floor support, minimizing postoperative recurrence, and causing relatively less surgical trauma. This method has become one of the preferred surgical options for managing moderate to severe POP and plays a vital role in enhancing patients' pelvic floor function and overall quality of life[5, 6].

1.3 Surgical Development

Transvaginal Sacrospinous Ligament Fixation (TV-SSLF) has been extensively utilized in clinical practice for an extended period, owing to its benefits, including a transvaginal approach, minimal trauma, absence of abdominal incision, expedited postoperative recovery, and reduced hospital stay. This technique is particularly advantageous for older patients, those with compromised physical conditions, or individuals unable to endure major surgical interventions. Nevertheless, this surgical method presents notable limitations. The narrow field of vision and challenging exposure during vaginal procedures complicate the positioning and suturing of the sacrospinous ligament, increasing the risk of ligament injury and bleeding. Furthermore, in patients with severe pelvic adhesions and significant prolapse, the operational difficulty escalates, potentially compromising surgical outcomes. As laparoscopic technology continues to advance and the principles of minimally invasive surgery gain traction, Transvaginal Natural Orifice Transluminal Endoscopic Surgery (vNOTES) has gradually found application in pelvic floor surgery. Transvaginal Natural Orifice Transluminal Endoscopic Sacrospinous Ligament Fixation (vNOTES-SSLF) retains the advantages of vaginal surgery, including the absence of abdominal incision and enhanced aesthetic outcomes.The magnified field of view provided by laparoscopy allows for a clear visualization of the anatomical structures within the pelvic cavity. This capability facilitates the precise identification of the sacrospinous ligament, thereby reducing the complexity of intraoperative procedures, minimizing intraoperative bleeding, and limiting damage to adjacent tissues. Consequently, patients experience less postoperative pain and achieve faster recovery times. The clinical advantages of this technique are becoming increasingly evident. Nevertheless, further research is required to enhance the understanding of the clinical efficacy, safety, and long-term prognosis of vNOTES-SSLF[7–9].

1.4 Research Objectives and Significance

In recent years, the clinical application of vNOTES-SSLF has steadily increased. However, its clinical efficacy, perioperative safety, postoperative recovery, and impact on pelvic floor function remain contentious when compared to traditional vaginal sacrospinous ligament fixation. Additionally, there is a paucity of large-sample, long-term follow-up retrospective studies to substantiate these claims[10]. In response, this study retrospectively analyzed the clinical data of patients with moderate to severe pelvic organ prolapse admitted to our hospital. We compared the perioperative indicators, short-term efficacy, and incidence of postoperative complications between vNOTES-SSLF and TV-SSLF, elucidating the clinical advantages and disadvantages of both surgical techniques. This analysis aims to provide a reliable evidence-based foundation for selecting

safer and more effective surgical approaches in the clinical management of moderate to severe pelvic organ prolapse, while also serving as a reference for future clinical research in this domain, thereby advancing the field of minimally invasive pelvic floor surgery.

2. Materials and Methods

2.1 Research Object

2.1.1 Inclusion criteria: Meeting the diagnosis of pelvic organ prolapse and preoperative POP-Q stage III or IV;Age ≥ 40 years old, with surgical indications; The clinical and follow-up data were complete, and the 6-month follow-up after the operation was completed.Sign the informed consent form for the surgery.

2.1.2 Exclusion criteria: Patients with severe heart, liver and kidney diseases, coagulation dysfunction, and severe pelvic adhesions; Patients who have previously undergone hysterectomy, have absolute contraindications for laparoscopic surgery, and have gynecological malignant tumors; The follow-up data is incomplete.

2.1.3 Grouping Method: Patients with moderate to severe POP who underwent sacrospinous ligament fixation in the gynecology department of our hospital from July 2023 to December 2025 were collected and divided into the experimental group (vNOTES-SSLF, n = 20) and the control group (TV-SSLF, n = 100) according to the surgical methods. Baseline data of the two groups of patients were collected.

2.2 Surgical Methods

2.2.1 Control group (TV-SSLF) operation process

Assume the lithotomy position, routinely disinfect the area, and drape a sterile cloth. Expose the superior aspect of the vagina and make an arc-shaped incision along the posterior vaginal mucosa. Carefully separate the pararectal space to the sacrospinous ligament, ensuring that surrounding organs, blood vessels, and nerves remain undamaged. The sacrospinous ligament, located 2.0-2.5 cm from the inner side of the ischial spine, is then clamped with vascular forceps. Intermittently suture 2–3 stitches with non-absorbable sutures to securely attach the superior aspect of the vagina to the ligament. Adjust the tension of the sutures, confirming the absence of active bleeding. Finally, suture the vaginal mucosa incision and place a urinary catheter postoperatively.

2.2.2 Experimental Group (vNOTES-SSLF) Operation process

The patient is positioned in the bladder lithotomy position, which is routinely disinfected and draped with a cloth. A longitudinal incision measuring 1.5-2.0 cm is made in the posterior vaginal vault to separate the rectovaginal space and establish pneumoperitoneum, maintaining a pressure of 12–14 mmHg. A single-port laparoscopic puncture cannula and laparoscopic instruments are introduced, allowing for further separation under direct laparoscopic visualization. The sacrospinous ligament, along with its adjacent nerves and blood vessels, including the pudendal nerve, sacral nerve, and internal pudendal artery, must be clearly exposed to prevent damage to critical tissues and organs. Utilizing specialized laparoscopic suture instruments, 2–3 non-absorbable sutures are placed at the optimal anchor point of the sacrospinous ligament under direct visualization. The vaginal tip or cervix is then suspended and fixed, with tension adjusted to restore the normal anatomical position of the vaginal tip. After confirming the absence of bleeding, the pneumoperitoneum is released, and the posterior fornix incision of the vagina is sutured in layers, with a urinary catheter subsequently placed.

2.2.3 Postoperative Management

After the operation, the patient should lie flat without a pillow for 6 hours. Vital signs must be monitored until they stabilize. Close observation of vaginal bleeding, abdominal pain, and abdominal signs is essential. The external genitalia should be kept clean and disinfected twice daily with iodophor to prevent infection. Patients should be guided to maintain a light diet, ensure smooth bowel movements, and minimize abdominal pressure on the pelvic floor. Following the operation,

cephalosporin antibiotics will be administered, with a switch to quinolones for those with allergies, to prevent infection. For patients experiencing significant pain, non-steroidal analgesics such as ibuprofen should be provided for symptomatic relief. One week post-operation, patients will be instructed to perform Kegel exercises to gradually strengthen the pelvic floor muscles. Patients should be informed to avoid sexual activity, tub bathing, and heavy physical labor for three months after the operation. They should also refrain from strenuous exercise, attend regular check-ups, and seek medical attention promptly if any abnormalities arise. Concurrently, health education will be provided to encourage patients to develop healthy lifestyle habits, control their weight, prevent constipation and chronic cough, and reduce the risk of pelvic organ prolapse recurrence.

2.3 Observation Indicators

2.3.1 Baseline data: age, BMI, number of pregnancies, number of deliveries, history of pelvic and abdominal surgeries.

2.3.2 Perioperative indicators: Operation time, intraoperative blood loss, 24-hour postoperative Visual Analogue Scale (VAS),time to first postoperative flatus, and hospital stay[11].

2.3.3 Short-term efficacy: POP-Q score before the operation and 3 months after the operation, Pelvic Floor Distress Inventory Short Form 20 PFDI-20), Pelvic Floor Impact Questionnaire Short Form 7 PFIQ-7), Patient Global Impression of Improvement (PGI-I) score[12, 13].

2.3.4 Safety indicators: Incidence of postoperative complications (urinary retention, residual bleeding/infection, pelvic pain, urinary tract infection).

2.4 Follow-up Methods

Follow-up was conducted at 3 months and 6 months after the operation. Relevant data were collected through gynecological examination, pelvic floor function assessment, telephone follow-up and other methods.

2.5 Statistical Methods

The data were analyzed and statistically processed using SPSS 26.0 statistical software. Measurement data conforming to a normal distribution were presented as mean ± standard deviation, with the independent sample t-test employed for analysis. For data not conforming to a normal distribution, the median (P25, P75) was utilized for representation, and the Mann-Whitney U rank sum test was applied. Count data were expressed as frequency or percentage (%). When the total sample size was ≥ 40 and all theoretical frequencies were ≥ 5, the chi-square test was conducted; otherwise, Fisher's exact probability method was utilized. A P value < 0.05 was deemed statistically significant.

2.6 Propensity Score Matching

Baseline bias was eliminated by using nearest neighbor matching with a propensity score of 1:4. Covariates included age, BMI, number of pregnancies, number of deliveries, history of pelvic and abdominal surgeries, and the clamp value was 0.03.

3. Results

3.1 Comparison of general data before and after propensity score matching

The two groups differed statistically significantly in age and parity before matching (P < 0.05).After 1:4 propensity score matching, there was no statistically significant difference in baseline data between the two groups (P > 0.05), and they were comparable, as shown in Tables 1 and 2.

Table 1
Comparison of general data of the first two groups in propensity score matching

Indicators	Experimental group (n = 20)	Control group (n = 100)	Statistics	*P*
Age (years)	61.05 ± 4.54	56.20 ± 8.05	t=-2.607	0.010
BMI(kg/m²)	23.46 ± 2.27	24.82 ± 3.16	t = 1.834	0.070
Number of Pregnancies	2.50(2.00,4.00)	3.00(2.75,4.00)	Z = 2.014	0.038
Parity	1.00(1.00,3.00)	2.00(2.00,2.00)	Z = 0.944	0.301
History of pelvic and abdominal surgery [n (%)]	15(75.00)/5(25.00)	81(81.00)/19(19.00)	x^2=0.094	0.759

Table 2
Comparison of general data between the two groups after propensity score matching

Indicators	Experimental group (n = 20)	Control group (n = 80)	Statistics	*P*
Age (years)	61.05 ± 4.54	58.66 ± 7.07	t=--1.601	0.113
BMI(kg/m²)	23.46 ± 2.27	23.99 ± 2.93	t = 0.765	0.446
Number of Pregnancies	2.50(2.00,4.00)	3.00(2.00,4.000)	Z = 1.008	0.293
Parity	1.00(1.00,3.00)	2.00(1.00,2.00)	Z = 0.724	0.441
History of pelvic and abdominal surgery [n (%)]	15(75.00)/5(25.00)	61(76.25)/19(23.75)	x^2=0.00	1.000

3.2 Comparison of perioperative indicators between the two groups

The operation time of the experimental group was longer than that of the control group. The intraoperative blood loss, 24-hour postoperative VAS score, postoperative exhaust time and hospital stay of the experimental group were all better than those of the control group, and the differences were statistically significant (P < 0.05), as shown in Table 3.

Table 3
Comparison of perioperative Indicators between the two groups

Indicators	Experimental group (n = 20)	Control group (n = 80)	Statistics	*P*
Operation time(min)	119.60 ± 21.63	90.86 ± 18.93	t = 5.901	< 0.001
Intraoperative blood loss(ml)	45.50 ± 11.46	54.88 ± 9.14	t=-3.893	< 0.001
24-hour postoperative VAS score	2.00(1.00,2.25)	4.00(3.00,4.00)	Z=-6.377	< 0.001
Postoperative exhaust time(d)	2.00(1.75,2.25)	2.00(1.00,2.00)	Z = 2.521	0.004
Hospital stay(d)	4.00(3.00,4.00)	5.00(4.00, 6.00)	Z=-3.249	< 0.001

3.2 Comparison of short-term postoperative efficacy between the two groups

Three months after the operation, each indicator point of POP-Q in the experimental group was significantly improved compared with that before the operation (P < 0.05). The C point in the experimental group improved significantly compared with the control group 6 months after the operation, and the difference was statistically significant (P < 0.05), as shown in Tables 4 and 5.

Table 4
Comparison of POP-Q staging indicators in the experimental group before the operation and one month after the operation

Preoperative	**Aa**	**Ba**	**C**	**Ap**	**Bp**
	1.00(0.00,2.00)	**1.00(0.75,1.25)**	**1.00(0.75,1.25)**	**-1.00(-1.00,-1.00)**	**-1.00(-2.00,0.00)**
6 months after surgery	-2.00(-3.00,-1.00)	-2.00(-3.00,-1.00)	-5.00(-6.00,-4.00)	-3.00(-3.00,-2.00)	-2.00(-3.00,-1.00)
Statistics	Z = 5.031	Z = 5.140	Z = 5.410	Z = 4.003	Z = 2.272
P	< 0.001	< 0.001	< 0.001	< 0.001	0.020

Table 5
Comparison of POP-Q staging indicators between the experimental group and the control group 6 months after surgery

	Aa	**Ba**	**C**	**Ap**	**Bp**
Experimental group	**-2.00(-3.00,-1.00)**	**2.00(-3.00,-1.00)**	**-5.00(-6.00,-4.00)**	**-2.00(-3.00,-1.00)**	**-2.00(-3.00,-1.00)**
Control group	-2.00(-3.00,-1.75)	-2.50(-3.25,-1.75)	-6.00(-7.00,-5.00)	-2.50(-3.25,-1.75)	-2.00(-3.00,-1.00)
Statistics	1.181	1.896	2.658	1.896	1.146
P	0.219	0.050	0.006	0.050	0.234

3.3 Comparison of short-term postoperative efficacy between the two groups

There was no statistically significant difference in the preoperative PFDI-20 and PFIQ-7 scores between the two groups (P > 0.05). Six months after the operation, the scores of both groups decreased significantly, and there was no statistically significant difference between the groups (P > 0.05). There was no statistically significant difference in the improvement rate of PGI-I between groups (P > 0.05), as shown in Table 6.

Table 6
Comparison of short-term Postoperative efficacy between the two groups

Rating	**Time**	**Experimental group**	**Control group**	**t**	***P***
PFDI-20	Preoperative	108.0 ± 12.503	107.85 ± 5.174	0.053	0.958
	6 months after surgery	30.65 ± 1.927	30.75 ± 1.372	-0.199	0.844
PFIQ-7	Preoperative	107.5 ± 5.735	105.85 ± 5.174	0.871	0.395
	6 months after surgery	30.6 ± 1.818	30.75 ± 1.372	-0.292	0.774
Improvement rate of PGI-I	6 months after surgery	19(95.0%)	75(93.75%)	0.492	0.483

3.4 Comparison of Postoperative Complications between the two groups

The incidence of pelvic pain and total complications in the experimental group was lower than that in the control group, and the difference was statistically significant. (P < 0.05), with good safety, as shown in Table 7.

Table 7
Comparison of Postoperative Complications between the two groups

Complications	Experimental group(n = 20)	Control group(n = 80)	χ^2	*P*
Urinary retention	1(5.00)	7(8.75)	-	1.000
Bleeding from the stump / Infection	0(0)	4(5.00)	-	0.581
Pelvic Pain	0(0)	15(18.75)	-	0.037
Urinary Tract Infection	0(0)	2(2.5)	-	1.000
Overall Complications	1(5.00)	28(35.00)	-	0.006

4. Discussion

4.1 Analysis of Differences in Perioperative Indicators between the Two Surgical Methods

The experimental group utilized vNOTES-SSLF, which offers significant advantages due to its minimally invasive nature and the enhanced visual field provided by laparoscopic technology. These features contribute to reduced intraoperative bleeding and expedited postoperative recovery. This surgical technique establishes a single-port access channel via the natural vaginal cavity, eliminating the need for abdominal incisions. Only endoscopic instruments are introduced through a small vaginal incision. In comparison to traditional vaginal surgery, this approach inflicts less damage on the pelvic and abdominal wall tissues, with trauma confined primarily to the local vaginal area. Consequently, this minimizes intraoperative bleeding, mitigates postoperative inflammatory responses at the incision site, and promotes rapid patient recovery[14]. Furthermore, laparoscopic instruments afford a high-magnification view of the pelvic region, allowing for clear visualization of the sacrospinous ligament, surrounding blood vessels, nerves, and pelvic organs. Surgeons can accurately identify the sacrospinous ligament within this enhanced field of view, enabling precise clamping and suturing while effectively avoiding major blood vessels and nerve structures in the pelvic cavity. This method circumvents the limitations of traditional vaginal surgical techniques, which often involve a restricted field of vision and challenging exposure, thereby reducing the risk of bleeding from vascular injuries and ligament tears, as well as minimizing traction and damage to adjacent normal tissues during the procedure[15, 16].Although TV-SSLF employs a transvaginal approach and direct operation without the need for laparoscopic equipment, the surgical process remains relatively straightforward. However, the limited space within the vaginal cavity severely restricts the surgical field of vision. Consequently, the surgeon must primarily rely on tactile feedback and experience, which complicates the clear identification of fine anatomical structures in the pelvic cavity. This reliance not only heightens the difficulty of accurately positioning and suturing the sacrospinous ligament but also increases the risk of damaging surrounding blood vessels, the rectum, or the bladder, leading to a notable rise in intraoperative blood loss. Furthermore, during the separation of the pararectal space and exposure of the sacrospinous ligament using traditional vaginal surgical techniques, the traction and damage to the vaginal mucosa and adjacent soft tissues are pronounced. The resultant local tissue edema and inflammatory response are more significant postoperatively, prolonging the recovery of intestinal function and extending the duration of hospital stay, ultimately resulting in a slower overall recovery compared to the observation group[17, 18].

4.2 Analysis of the Differences in Therapeutic Effects and Pelvic Floor Function Recovery between the Two Surgical Methods

The primary objectives of both surgical techniques for the treatment of POP are to restore the pelvic floor's supporting structures, rectify organ prolapse, and enhance pelvic floor function. However, variations in surgical pathways, clarity of the visual field, and the extent of tissue trauma result in differences in the accuracy of prolapse correction and the efficacy of pelvic floor function improvement between the two methods. This discrepancy is the fundamental reason for the superior

recovery of pelvic floor function observed in the experimental group. Both surgical approaches address prolapse by anchoring the vaginal apex to the sacrospinous ligament, thereby reconstructing the first-level suspension support of the pelvic floor. Nonetheless, the precision of fixation significantly influences treatment outcomes and the restoration of pelvic floor function[19–21]. The vNOTES-SSLF technique offers clear delineation of the sacrospinous ligament and the surrounding anatomical structures, enabling precise selection of robust, vascularized areas for suture fixation. This ensures accurate fixation points and uniform tension, facilitating not only the correction of prolapse but also the prevention of uneven force distribution across the pelvic floor support structures. In contrast, the TV-SSLF technique is constrained by the limited visual field within the narrow vaginal cavity. Consequently, surgeons predominantly rely on their experience for positioning and fixation, which may lead to deviations in the fixation site and uneven tension, complicating the achievement of precise repairs.During the separation and exposure process, the pelvic floor muscles and fascia are susceptible to pulling and damage. This vulnerability contributes to a relatively high incidence of postoperative tissue edema and adhesion, which impairs the contraction function of the pelvic floor muscles. From the perspective of enhancing pelvic floor function, the precise fixation employed in the observation group minimizes organ compression and traction on the pelvic floor muscles, resulting in reduced trauma and postoperative pain. Consequently, patients in this group could initiate pelvic floor rehabilitation exercises earlier, demonstrate higher compliance, and achieve more favorable recovery of pelvic floor muscle strength. In contrast, the control group experienced poor recovery of pelvic floor function due to significant postoperative pain, slower recovery, delayed initiation of rehabilitation exercises, and the effects of tissue damage[22].

4.3 Safety Analysis of Two Surgical Methods

Surgical safety serves as the primary indicator for assessing the therapeutic efficacy of POP surgery. The incidence of complications associated with both surgical techniques is closely linked to surgical trauma, adherence to standardized procedures, and postoperative care. Among these factors, the extent of trauma and the precision of the operation are critical determinants.VNOTES demonstrates notable safety advantages[23]. Relevant studies indicate that common complications arising from both surgical methods include intraoperative and postoperative bleeding, pelvic infections, abnormal urination, pelvic pain, and gluteal myositis, all of which are specifically associated with the characteristics of the surgical procedures[24–27]. Regarding infection, a greater degree of trauma and less adherence to aseptic techniques correlate with an increased risk of infection. The limited visibility in the vaginal field during TV-SSLF exacerbates tissue traction injuries during the procedure. Poor exposure of the surgical field often leads to non-standard aseptic practices, thereby heightening the risk of infection. In contrast, vNOTES-SSLF is highly minimally invasive, resulting in limited trauma. The enhanced visibility provided by laparoscopy promotes standardized aseptic techniques, and when combined with unified postoperative care, significantly reduces the incidence of infection. Concerning bleeding, this complication primarily relates to the precision of the surgical technique. TV-SSLF is more susceptible to damaging blood vessels or tearing ligaments, and some surgeons who perform sutures too superficially further elevate the risk of bleeding.vNOTES-SSLF can accurately identify blood vessels and nerves. When performed under direct vision, it effectively avoids blood vessels and precisely controls bleeding, leading to a reduction in bleeding complications. Among other complications, abnormal urination and pelvic pain primarily result from neuromuscular injury to the pelvic floor. The traction injury associated with TV-SSLF is significant. The incidence of postoperative edema and adhesion is high, with symptoms being particularly pronounced. In contrast, vNOTES-SSLF involves minimal trauma and allows for precise operation, thereby effectively reducing these complications.

4.4 Research Limitations

This study is a retrospective comparative analysis and has inherent limitations. Future research should implement a large-sample, multi-center randomized controlled trial design. It is essential to extend the follow-up period to one year or longer, systematically collecting data on long-term efficacy, recurrence rates, and complications to comprehensively assess the long-term clinical value of the two surgical methods. Additionally, expanding the range of observational indicators to include patients' subjective quality of life scores and long-term recovery of sexual function is crucial. Increasing stratified analyses based on different prolapse scores and comorbidities will further refine individualized surgical method selection recommendations. Moreover, integrating multi-center clinical data will enhance the objectivity, reliability, and clinical

applicability of the research findings, thereby providing more robust evidence-based support for the treatment of pelvic organ prolapse.

4.5 Prospects for Clinical Application

The optimization of vNOTES can focus on enhancing operational convenience and safety. By improving specialized instruments, integrating digital navigation technology, and optimizing surgical procedures, the operational difficulty can be reduced and its popularization at the grassroots level can be promoted[28–30]. This technology has broad application prospects in the treatment of POP. With its minimally invasive and precise advantages, it is expected to become the preferred surgical method for moderate to severe POP. It can be combined with pelvic floor rehabilitation to form an integrated treatment plan, meeting the needs of different groups of people. Clinically, the surgical method should be selected on an individualized basis based on the patient's age, the degree of prolapse, comorbidities and personal preferences. Complex cases require comprehensive assessment. At the same time, health education and postoperative rehabilitation should be strengthened to promote the development of POP treatment towards precision, individualization and safety.

5. Conclusion

This study conducted a retrospective comparison of the clinical outcomes associated with vNOTES-SSLF and TV-SSLF in the treatment of POP. The findings indicated no statistically significant differences in baseline characteristics between the two patient groups, demonstrating their comparability. vNOTES-SSLF exhibited significant superiority over TV-SSLF concerning perioperative metrics, including intraoperative blood loss, postoperative hospital stay, time to postoperative exhaust, overall hospital stay, and the 24-hour VAS score following surgery, as well as the incidence of complications. Although the operative time for vNOTES-SSLF was longer, the C-point at six months post-surgery showed significant improvement compared to TV-SSLF. There were no notable differences in short-term postoperative efficacy between the two techniques. A comprehensive analysis of the strengths and weaknesses of both surgical approaches reveals that vNOTES-SSLF offers greater advantages in preserving pelvic floor function, attributable to its benefits of enhanced visualization, reduced trauma, expedited recovery, and high safety profile. In contrast, while TV-SSLF can achieve basic correction of prolapse, it is associated with limitations such as a restricted visual field, greater trauma, and prolonged recovery time.Surgical approaches should be chosen based on individual clinical needs, as complex cases necessitate a thorough evaluation that considers the surgeon's expertise. The findings of this study offer reliable, evidence-based recommendations for selecting surgical procedures for POP, demonstrating that the vNOTES-SSLF technique is both effective and safe. This technique may be regarded as one of the preferred surgical options for the clinical management of POP, contributing to enhanced treatment outcomes and improved long-term quality of life for patients.

Abbreviations

POP
Pelvic Organ Prolapse
vNOTES
Transvaginal Natural Orifice Transluminal Endoscopic Surgery
vNOTES-SSLF
Transvaginal Natural Orifice Transluminal Endoscopic Sacrospinous Ligament Fixation
TV-SSLF
Vaginal Sacrospinous Ligament Fixation
POP-Q
Pelvic Organ Prolapse Quantification System
VAS
Visual Analogue Scale
PFDI-20

Pelvic Floor Distress Inventory Short Form 20
PFIQ-7
Pelvic Floor Impact Questionnaire Short Form 7
PGI-I
Patient Global Impression of Improvement

Declarations

Ethics approval and consent to participate

This retrospective comparative study was conducted in accordance with the Declaration of Helsinki and relevant national ethical guidelines for biomedical research involving human subjects. The study protocol was reviewed and approved by the Ethics Committee of Inner Mongolia People's Hospital, Ethics Approval No. SC-07/02KT2025077Y, approval date: December 31, 2025. All participants provided written informed consent before enrollment. All clinical data of patients were fully anonymized to protect personal privacy and avoid identification of individuals.

Consent for publication

Not Applicable. No identifiable images, personal clinical details or individual participant information that may break anonymity were included in this manuscript.

Competing Interests

The authors declare no conflicts of interest.

Funding

This research received no external funding.

Author Contribution

L.L. Liang: conceptualization, methodology, formal analysis, writing – original draft;Y.G. Ao: statistical analysis, software;J. Liu,Y. Tian and X.W. Zhang: literature research;Y.L. Wang:project management, manuscript revision and polishing, correspondence author.All authors have read and agreed to the published version of the manuscript.

Acknowledgement

We sincerely thank all gynecological medical staff of Inner Mongolia Autonomous Region People's Hospital for their assistance in clinical data collection and postoperative follow-up of patients with pelvic organ prolapse. We also appreciate all patients who participated in this retrospective study for their cooperation during clinical visits and follow-up interviews.

Availability of data and materials

The data supporting the findings of this study are not publicly available due to privacy and ethical restrictions, but may be made available from the corresponding author upon reasonable request and with permission from the relevant institutional authorities.

References

1. Collins SA, O'Shea M, Dykes N et al. International Urogynecological Consultation: clinical definition of pelvic organ prolapse. Int Urogynecol J 2021, 32(6).
2. Wang R, Li W, Yang J, et al. A cross-sectional analysis based on GBD data: trends in the global, regional, and national burden of pelvic organ prolapse from 1990 to 2021. Front Public Health. 2025;13:1555946.
3. KatieJay D, Mansi A, Phoebe M, et al. The relationship between symptom severity, bother and psychological factors in women with pelvic organ prolapse: A cross-sectional observational study. Neurourol Urodyn. 2021;41(1):423–31.
4. Musa K, Kabonge DK, Richard M, et al. Impact of surgery on quality of life of Ugandan women with symptomatic pelvic organ prolapse: a prospective cohort study. BMC Womens Health. 2021;21(1):258.
5. Wighton N, Sciscione A. Pelvic Organ Prolapse. Elsevier Inc; 2026.
6. Isuzu M, TCB MJS, et al. Five-year surgical outcomes of transvaginal apical approaches in women with advanced pelvic organ prolapse. Int Urogynecol J. 2023;34(9):2171–81.
7. Lyu Y, Ding H, Ding J, et al. Single-port laparoscopic sacrospinous ligament suspension via the natural vaginal cavity (SvNOTES) for pelvic prolapse: The first feasibility study. Front Surg. 2022;9:911553.
8. Huang L, Yu J, Li Y, et al. Transvaginal natural orifice transluminal endoscopic surgery versus conventional vaginal surgery for sacrospinous ligament fixation of apical compartment prolapse: a retrospective analysis. BMC Surg. 2023;23(1):24.
9. Qin Z, Dong Z, Tang H, et al. A preliminary clinical report of transvaginal natural orifice transluminal endoscopic Sacrospinous Ligament Fixation in the treatment of moderate and severe pelvic organ prolapse. Front Surg. 2022;9:931691.
10. Athanasiou S, Prodromidou A, Zacharakis D, et al. Technical Challenges and Surgical Considerations in Sacrospinous Ligament Fixation for Apical Prolapse Repair. J Clin Med. 2026;15(11):4209.
11. Huskisson EC. Measurement of pain. Lancet. 1974;2(7889):1127–31.
12. Avery JC, Shaw JM, Coon JS, et al. Short forms of two condition-specific quality-of-life questionnaires for women with pelvic floor disorders (PFDI-20 and PFIQ-7). Am J Obstet Gynecol. 2005;193(1):103–13.
13. Srikrishna S, Robinson D, Cardozo L. Validation of the Patient Global Impression of Improvement (PGI-I) for urogenital prolapse. Int Urogynecol J. 2010;21(5):543–8.
14. Kanmaz AG, Tz E, Akpak YK. V-notes Sacrospinous Ligament Fixation for the Treatment of Apical Vaginal Prolapse. Gynecol Minim Invasive Ther 2025, 14(3).
15. Chene G, Cerruto E, Moret S, et al. Gasless transvaginal natural orifice transluminal endoscopic surgery (vNOTES) for sacrospinous fixation: An anatomical study. Eur J Obstet Gynecol Reprod Biol. 2025;318:114897.
16. Ye L, Chao W, Xianjing W, et al. Case report: Transvaginal single-port extraperitoneal laparoscopic sacrospinous ligament fixation for apical prolapse: A single-center case series. Front Surg. 2023;10:1066622.
17. Athanasiou S, Prodromidou A, Zacharakis D, et al. Technical Challenges and Surgical Considerations in Sacrospinous Ligament Fixation for Apical Prolapse Repair. J Clin Med. 2026;15(11):4209.
18. Vacca L, Rosato E, Lombardo R, et al. Transvaginal Natural Orifice Transluminal Endoscopic Surgery (vNOTES) in Urogynecological Surgery: A Systematic Review. J Clin Med. 2024;13(19):5707.
19. Peker N, Balkan BS, Ege S, et al. A new technique for sacrospinous ligament fixation: endoscopic sacrospinous ligament fixation (Peker technique). Ginekol Pol; 2025.
20. Vigna A, Barba M, Frigerio M. Long-Term Outcomes (10 Years) of Sacrospinous Ligament Fixation for Pelvic Organ Prolapse Repair. Healthcare. 2024;12(16):1611.
21. Chene G, Cerruto E, Moret S, et al. The vaginal minimally invasive sacrospinous fixation under visual guidance: A pilot study. Eur J Obstet Gynecol Reprod Biol. 2025;317:114866.

22. Lamberti G, Giraudo D, Ciardi G, et al. Pelvic Floor Muscle Training Following Surgery for Pelvic Organ Prolapse: Recommendation from Scientific Literature. J Clin Med. 2026;15(3):1116.
23. Stuart A, Wagenius J, Filho BL, et al. Intra- and Postoperative Complications in 4565 vNOTES Hysterectomies: International Registry Cohort Study. BJOG. 2024;132(4):464–72.
24. LingXiao H, Min G, LiXiao S et al. Clinical Effect of Uterosacral and Cardinal Ligament Fixation versus Sacrospinous Ligament Fixation of Vaginal Vault Prolapse: A Retrospective Analysis. Int J Clin Pract : 2023, 2023:1489928.
25. Susie GD, Brigitte F, Michel C, et al. Serious Complications and Recurrence following Sacrospinous Ligament Fixation for the Correction of Apical Prolapse. J Clin Med. 2023;12(2):468.
26. Rosenberg H, Haleluya LN, Saban A, et al. Trends in patient characteristics, surgical techniques, and associated complications over time in pelvic organ prolapse repair. Eur J Obstet Gynecol Reprod Biol. 2025;308:116–20.
27. Ping W, Mingyue L, Huating S, et al. Function, quality-of-life and complications after sacrospinous ligament fixation using an antegrade reusable suturing device (ARSD-Ney) at 6 and 12 months: a retrospective cohort study. Ann Transl Med. 2022;10(10):582.
28. Yang Q, Lovell YD, Guan X. Surgical Outcomes and Learning Curve of Robotic Single-Port Vaginal Natural Orifice Transluminal Endoscopic Surgery (vNOTES) Hysterectomy Using the Da Vinci Single-Port System. Cureus. 2026;18(1):e102729.
29. Zhang C, Huang Q, Hu X, et al. Application of single-port robotic systems in gynecologic vNOTES surgery. Intell Surg. 2026;9:14–8.
30. Li Y, Hou S, Li W, et al. Addressing Access and Visualization Limitations in VNOTES: Evaluation of a Novel Laparoscopic Vaginal Speculum in a Porcine Model. Surg Innov. 2025;33(3):15533506251410644.