

Efficacy of Intraoperative Adhesion Barrier Use in Laparoscopic Surgery for Endometriosis: A Single-Center Retrospective Study on Long-Term Recurrence and Pelvic Pain

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Objective: To evaluate the efficacy of intraoperative adhesion barriers in reducing long-term recurrence and alleviating pelvic pain in patients with endometriosis following laparoscopic surgery.

Methods: A retrospective analysis was performed on 1246 patients with endometriosis who underwent laparoscopic surgery at Jingzhou Central Hospital from January 2019 to December 2023. Based on the application of adhesion barriers, these patients were categorized into a barrier group (n=628) and a control group (n=618). Clinical data, along with follow-up data on recurrence and pelvic pain, were collected. The Kaplan-Meier method, Visual Analogue Scale (VAS), and multivariate Cox regression analysis were employed for statistical evaluation.

Results: The baseline characteristics between the two groups were comparable (both $P > 0.05$). The median follow-up duration was 36 months. The recurrence rate in the barrier group (15.29%) was significantly lower than that in the control group (26.38%, $P < 0.001$). Additionally, the VAS scores in the barrier group were consistently lower across all follow-up time points (all $P < 0.05$). The absence of adhesion barrier use, r-AFS stages III–IV, and incomplete lesion resection were identified as independent risk factors for recurrence. No significant adverse reactions were observed.

Conclusion: Intraoperative adhesion barriers can effectively reduce long-term recurrence and safely alleviate pelvic pain. However, the study's limitations, including its single-center retrospective design, necessitate further validation through large-scale, multicenter prospective studies.

Keywords: endometriosis, laparoscopic surgery, adhesion barrier, long-term recurrence, pelvic pain, retrospective study

Introduction

Endometriosis represents a prevalent chronic gynecological condition marked by the ectopic growth of endometrial tissue beyond the uterine cavity, predominantly impacting women of reproductive age.^{1,2} Its clinical presentations are varied, with pelvic pain and infertility standing out as the most significant, severely compromising both the physical and mental well-being, as well as the quality of life, of those affected.³ As minimally invasive surgical techniques continue to advance, laparoscopic surgery has emerged as the preferred surgical approach for treating endometriosis, owing to its merits of minimal trauma, swift recovery, and a clear surgical field.^{4,5} Nevertheless, the challenge of postoperative pelvic adhesions warrants due attention.

Postoperative pelvic adhesion represents a prevalent complication following gynecological laparoscopic surgery, with a notably high incidence rate among patients with endometriosis.^{6,7} The development of adhesions is intricately linked to

factors such as inflammatory responses triggered by surgical trauma and aberrant proliferation of fibroblasts.^{7–9} Adhesions not only induce persistent pelvic pain but also elevate the risk of disease recurrence by compromising the normal physiological architecture and function of the pelvic cavity.^{10,11} Furthermore, severe adhesions may augment the complexity of reoperation and heighten the risk of intraoperative complications. Consequently, devising effective strategies to prevent postoperative adhesions in endometriosis patients and enhance their long-term prognosis has emerged as a pivotal concern in clinical practice.

The application of adhesion barriers during surgical procedures represents a conventional approach for preventing postoperative pelvic adhesions.^{12,13} Currently, a diverse array of adhesive barriers are employed in clinical settings, including hyaluronic acid derivatives, collagen membranes, and modified starch materials.^{14–16} These materials are capable of forming a physical barrier on the surgical site's surface, thereby minimizing tissue adhesion and effectively preventing adhesion formation. Several short-term follow-up studies have indicated that adhesion barriers can diminish the incidence of postoperative adhesions; however, there is a scarcity of research examining their long-term efficacy in reducing the recurrence rate of endometriosis and relieving pelvic pain. Furthermore, the findings from existing studies exhibit inconsistency, potentially attributable to factors such as limited sample sizes, brief follow-up durations, and variations in the types of adhesion barriers utilized.

Therefore, this study conducted a retrospective analysis of 1,246 patients diagnosed with endometriosis who underwent laparoscopic surgery at our hospital over the past five years. By comparing the long-term recurrence rates and improvements in pelvic pain between patients who received intraoperative adhesion barriers and those who did not, we evaluated the efficacy and safety of adhesion barriers. This study aims to provide robust clinical evidence supporting the rational use of adhesion barriers in laparoscopic surgery for endometriosis, thereby enhancing the long-term management of this condition.

Methods

Study Population

A total of 1,523 patients with endometriosis who underwent laparoscopic surgery at the Obstetrics and Gynecology Department of Jingzhou Central Hospital between January 2019 and December 2023 were initially selected. The inclusion criteria were as follows: (1) Diagnosis of endometriosis confirmed by postoperative pathological examination; (2) Patients undergoing laparoscopic surgery for the first time; (3) Age ranging from 18 to 45 years old (inclusive); (4) Availability of complete clinical data and follow-up information. The exclusion criteria included: (1) Concomitant gynecological diseases, such as uterine fibroids, adenomyosis, or ovarian tumors; (2) Comorbidities including cardiovascular and cerebrovascular diseases, diabetes, liver or kidney dysfunction, and other serious systemic conditions; (3) Previous history of pelvic surgery; (4) Pregnancy or lactation during the study period; (5) Missing follow-up data or incomplete clinical records. Based on these criteria, 277 patients were excluded, leaving 1,246 patients for final inclusion. These patients were divided into a barrier group (n=628) and a control group (n=618) based on the use of intraoperative adhesion barriers (hyaluronic acid-based adhesion barriers, with their brand, composition, and standardized clinical application techniques having demonstrated favorable anti-adhesion effects in prior studies). The decision to use adhesion barriers was primarily based on the surgeon's preference and routine clinical protocols, rather than being selectively allocated according to the patient's baseline condition, disease severity, or surgical complexity. The patient inclusion and screening process is illustrated in [Figure 1](#).

Ethical Exemption Statement

This is a single-center retrospective study. All data were collected through a review of electronic medical records and follow-up records, with no additional interventions imposed on the patients. This study strictly conforms to the Declaration of Helsinki and relevant ethical guidelines for medical research. Patient personal information has been anonymized to safeguard privacy and security. Considering that this study involves retrospective data analysis and that data collection and utilization do not infringe upon patient rights, it has undergone review and received approval from the Ethics Committee of Jingzhou Central Hospital, along with ethical exemptions. The requirement for obtaining written

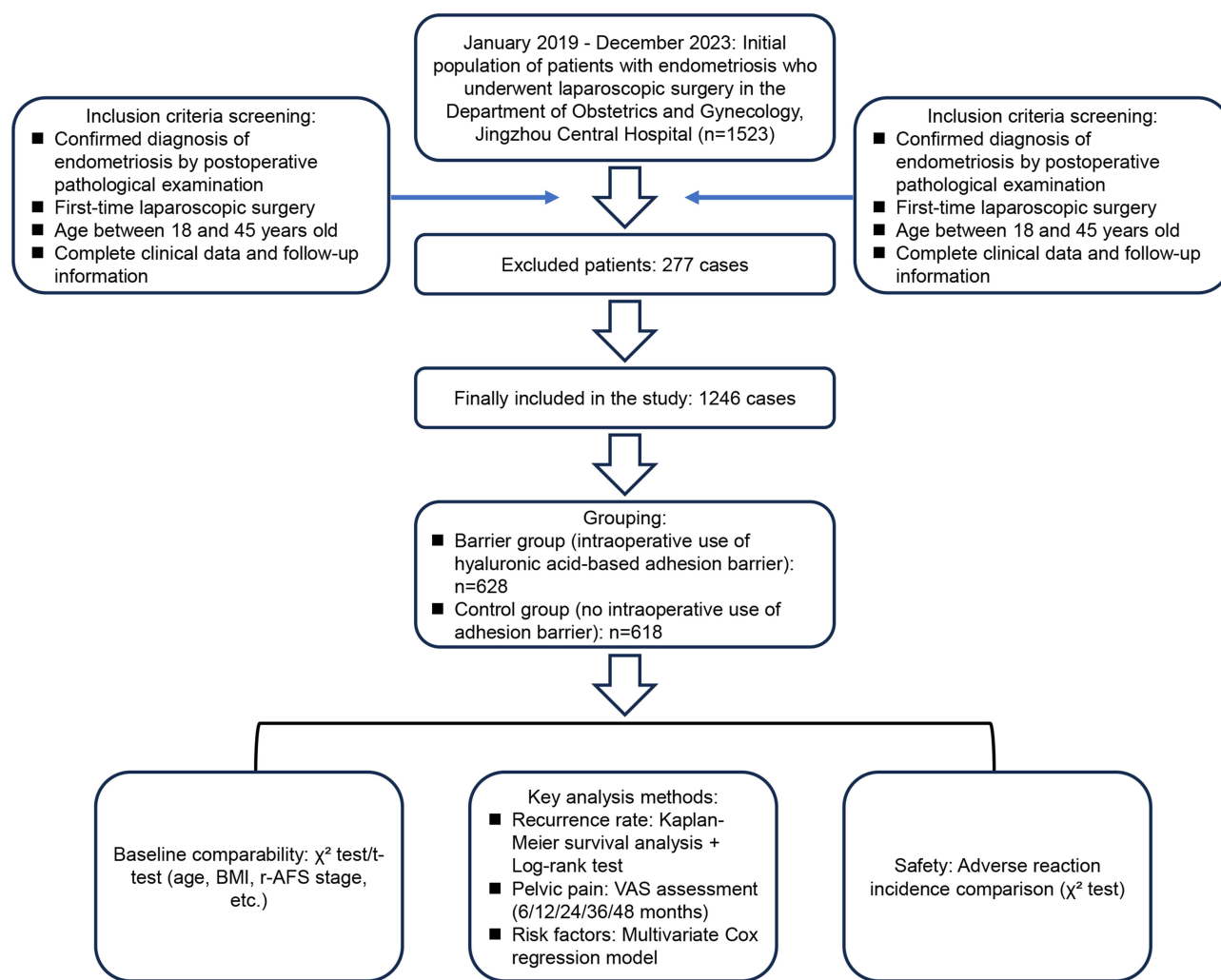


Figure 1 Flowchart of Patient Inclusion and Screening.

informed consent from patients has been waived. All data extraction and analysis procedures adhere to pertinent regulations governing medical data management.

Data Collection

Clinical data from the included patients were collected through a review of electronic medical records and follow-up records, encompassing: (1) Baseline information: age, body mass index (BMI), menstrual history, parity, history of dysmenorrhea, etc; (2) Surgical-related information: r-AFS staging (according to the revised American Fertility Society classification), lesion types (including ovarian endometriosis, peritoneal endometriosis, and deep infiltrating endometriosis), surgical methods (such as laparoscopic ovarian cystectomy and laparoscopic excision of pelvic endometriosis lesions), duration of surgery, intraoperative blood loss, and the use of adhesion barriers, among others; (3) Follow-up data: follow-up duration, recurrence of endometriosis (diagnosed based on clinical symptoms, gynecological examinations, and imaging studies), Visual Analog Scale (VAS) scores for pelvic pain at each follow-up time point (ranging from 0 to 10, with 0 indicating no pain and 10 indicating the most severe pain), and adverse reactions associated with adhesion barriers.

Follow-Up

All patients undergo regular postoperative follow-up. The follow-up modalities encompass outpatient visits, telephone consultations, and WeChat-based follow-up. The initial follow-up is conducted one month post-surgery, followed by

biannual follow-ups for the first two years, and subsequently annual follow-ups thereafter. The follow-up protocol includes inquiries about clinical symptoms (such as pelvic pain, dysmenorrhea, and irregular vaginal bleeding), gynecological examinations, and transvaginal ultrasound scans, among others. The follow-up period will conclude in December 2024, with the duration calculated from the surgery date to either the recurrence date or the date of the final follow-up.

Statistical Methods

Statistical analyses were performed using SPSS 26.0 and R 4.3.1 software. Measurement data conforming to a normal distribution are presented as mean $\pm$ standard deviation ($\bar{x} \pm s$), with independent sample t-tests employed for intergroup comparisons. For measurement data not conforming to a normal distribution, the median (interquartile range) [M (Q1, Q3)] is reported, and comparisons between groups are conducted using the Mann–Whitney *U*-test. Count data are expressed as the number of cases (percentage) [n (%)], with intergroup comparisons made using the chi-square test. The Kaplan–Meier method was utilized to plot recurrence-free survival curves, and the Log rank test was applied to compare recurrence-free survival rates between the two groups. Initially, a univariate Cox regression analysis was performed, and variables with $P < 0.1$ were incorporated into a multivariate Cox regression model to identify independent risk factors for long-term recurrence of endometriosis. A P -value < 0.05 was considered statistically significant.

Results

Baseline Characteristics of the Two Groups

This study enrolled a total of 1,246 patients, with 628 in the barrier group and 618 in the control group. A comparison of the baseline characteristics between the two groups revealed no statistically significant differences in age, BMI, parity, history of dysmenorrhea, r-AFS staging, lesion type, or surgical method (all $P > 0.05$), indicating that the two groups were comparable (as shown in Table 1).

Table 1 Baseline Characteristics of the Two Groups of Patients with Endometriosis

Characteristics	Barrier Group (n=628)	Control Group (n=618)	Statistic Value	P value
Age (years, $\bar{x} \pm s$)	32.64 $\pm$ 5.32	33.12 $\pm$ 5.67	$t=1.426$	0.154
BMI (kg/m^2 , $\bar{x} \pm s$)	22.35 $\pm$ 2.41	22.58 $\pm$ 2.56	$t=1.213$	0.225
Parity [n (%)]	–	–	$\chi^2=0.876$	0.349
Nulliparous	412 (65.61)	401 (64.89)	–	–
Multiparous	216 (34.39)	217 (35.11)	–	–
History of dysmenorrhea [n (%)]	–	–	$\chi^2=1.024$	0.312
Yes	532 (84.71)	520 (84.14)	–	–
No	96 (15.29)	98 (15.86)	–	–
r-AFS stage [n (%)]	–	–	$\chi^2=0.567$	0.451
I-II	286 (45.54)	281 (45.47)	–	–
III-IV	342 (54.46)	337 (54.53)	–	–
Lesion type [n (%)]	–	–	$\chi^2=2.135$	0.344
Ovarian endometrioma	365 (58.12)	358 (57.93)	–	–
Peritoneal endometriosis	186 (29.62)	192 (31.07)	–	–
Deep infiltrating endometriosis	77 (12.26)	68 (11.00)	–	–
Surgical method [n (%)]	–	–	$\chi^2=1.876$	0.391
Laparoscopic ovarian cystectomy	328 (52.23)	321 (51.94)	–	–
Laparoscopic lesion resection	236 (37.58)	242 (39.16)	–	–
Other laparoscopic surgeries	64 (10.19)	55 (8.90)	–	–

Note: BMI, body mass index; r-AFS, revised American Fertility Society classification; Data were expressed as mean $\pm$ standard deviation ($\bar{x} \pm s$), median (interquartile range) [M (Q1, Q3)] or number of cases (percentage) [n (%)]; Comparison between groups: t-test for measurement data conforming to normal distribution, Mann–Whitney *U*-test for measurement data not conforming to normal distribution, χ^2 -test for count data.

Long-Term Recurrence Rate of Endometriosis Between the Two Groups

The median follow-up duration for the 1,246 patients was 36 months, with a range of 6 to 60 months and an interquartile range of 24 to 48 months. During the follow-up period, endometriosis recurred in 259 patients, yielding an overall recurrence rate of 20.79%. Specifically, the barrier group experienced 96 recurrences, corresponding to a recurrence rate of 15.29%, whereas the control group had 163 recurrences, with a recurrence rate of 26.38%. The Log rank test revealed a significantly higher recurrence-free survival rate in the barrier group compared to the control group ($\chi^2=21.36$, $P<0.001$) (as depicted in Figure 2). This finding suggests that the intraoperative application of adhesion barriers can substantially reduce the long-term recurrence rate of endometriosis following laparoscopic surgery.

Comparison of Pelvic Pain VAS Scores Between the Two Groups During Long-Term Follow-Up

The pelvic pain Visual Analogue Scale (VAS) scores of the two groups were compared at various follow-up time points (6, 12, 24, 36, and 48 months). The findings revealed that, at each follow-up interval, the VAS scores in the barrier group were notably lower than those in the control group, with the differences reaching statistical significance (all $P < 0.05$) (as presented in Table 2). As the follow-up period progressed, both groups exhibited a declining trend in VAS scores; however, the barrier group consistently maintained lower scores compared to the control group. These results suggest that the intraoperative application of adhesion barriers can effectively provide long-term relief from pelvic pain in patients with endometriosis.

Multivariate Analysis of Risk Factors for Long-Term Recurrence of Endometriosis

A multivariate Cox proportional hazards regression model was constructed, utilizing endometriosis recurrence (coded as 1 for recurrence and 0 for no recurrence) as the dependent variable, and incorporating factors with a P -value < 0.1 from univariate analysis (including age, BMI, r-AFS stage, lesion type, surgical method, utilization of an adhesion barrier, and

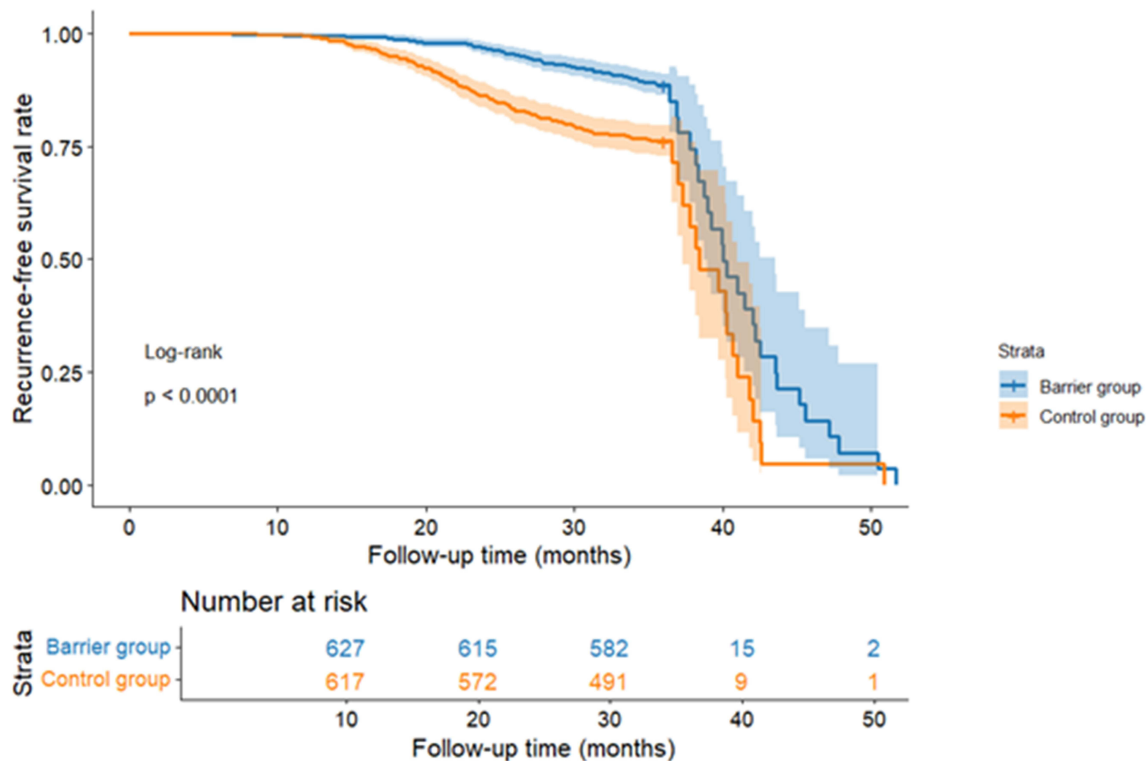


Figure 2 Kaplan-Meier recurrence-free survival curve of the two groups of patients with endometriosis.

Note: The horizontal axis represents the follow-up time (months), and the vertical axis represents the recurrence-free survival rate. The Log rank test showed that the recurrence-free survival rate of the barrier group was significantly higher than that of the control group ($\chi^2=21.36$, $P < 0.001$).

Table 2 Comparison of Pelvic Pain VAS Scores Between the Two Groups at Different Follow-Up Time Points ($\bar{X} \pm s$, Points)

Follow-Up Time (Months)	Barrier Group (n=628)	Control Group (n=618)	t value	P value
6	2.34 $\pm$ 0.87	3.12 $\pm$ 1.05	12.654	< 0.001*
12	1.87 $\pm$ 0.76	2.65 $\pm$ 0.98	11.327	< 0.001*
24	1.56 $\pm$ 0.68	2.23 $\pm$ 0.87	10.876	< 0.001*
36	1.34 $\pm$ 0.59	1.98 $\pm$ 0.76	10.234	< 0.001*
48	1.12 $\pm$ 0.51	1.76 $\pm$ 0.68	9.876	< 0.001*

Note: VAS, visual analog scale; Compared with the control group at the same time point, *P < 0.05.

Table 3 Multivariate Cox Regression Analysis of Risk Factors for Long-Term Recurrence of Endometriosis

Variables	HR	95% CI	χ^2 value	P value
Age (years)	1.02	0.98–1.06	0.876	0.349
BMI (kg/m ²)	1.03	0.99–1.07	1.213	0.225
Whether adhesion barrier was used (0=yes, 1=no)	1.87	1.42–2.46	26.345	< 0.001
r-AFS stage (0=I-II, 1=III-IV)	2.31	1.68–3.18	32.123	< 0.001
Lesion type (0=ovarian endometrioma, 1=others)	1.23	0.98–1.56	3.124	0.077
Whether lesion resection was complete (0=yes, 1=no)	2.05	1.53–2.75	28.765	< 0.001

Note: HR, hazard ratio; CI, confidence interval; Reference group: use of adhesion barrier for “whether adhesion barrier was used”; r-AFS I-II stage for “r-AFS stage”; complete lesion resection for “whether lesion resection was complete”.

completeness of lesion resection) as independent variables. The findings revealed that the absence of adhesion barrier usage during surgery (HR = 1.87, 95% CI: 1.42–2.46, $P < 0.001$), r-AFS stage III–IV (HR = 2.31, 95% CI: 1.68–3.18, $P < 0.001$), and incomplete lesion resection (HR = 2.05, 95% CI: 1.53–2.75, $P < 0.001$) constituted independent risk factors for the long-term recurrence of endometriosis (as delineated in Table 3). This outcome further substantiates that the application of adhesion barriers serves as a significant protective factor in mitigating the long-term recurrence of endometriosis.

Safety Evaluation of Adhesion Barrier

Throughout the follow-up period, the barrier group exhibited no notable adverse reactions associated with the adhesion barrier, including allergic responses, infections, abnormal vaginal bleeding, fever, or local irritation. The incidence of adverse events did not significantly differ between the barrier group and the control group ($P > 0.05$). This suggests that the application of hyaluronic acid-based adhesion barriers in laparoscopic surgery for endometriosis is both safe and reliable.

Discussion

Endometriosis is a chronic condition characterized by a high recurrence rate, with postoperative adhesions serving as significant factors influencing disease relapse and long-term prognosis.^{17,18} Laparoscopic surgery, recognized as a minimally invasive therapeutic approach, has been extensively employed in clinical settings; however, it cannot entirely preclude the occurrence of postoperative adhesions.^{19,20} Consequently, investigating effective strategies to prevent postoperative adhesions holds substantial importance for enhancing the long-term prognosis of patients with endometriosis. This study primarily examines the long-term efficacy of adhesion barriers utilized during laparoscopic surgery for endometriosis. The findings indicate that adhesion barriers can markedly diminish long-term recurrence rates, mitigate pelvic pain, and furnish crucial clinical evidence supporting the judicious application of adhesion barriers.

The balance of baseline data between the two groups serves as a prerequisite for ensuring the reliability of research findings. In this study, no significant differences were observed between the barrier group and the control group concerning age, BMI, r-AFS staging, lesion type, and other baseline characteristics. This suggests that the patient grouping was rational and the influence of confounding factors on the study outcomes was minimized. In line with this, the majority of retrospective studies on endometriosis also emphasize the balance of baseline data across groups to ensure the comparability of research results. For instance, a systematic review conducted by Schaefer et al focused on the prevention of peritoneal adhesions following gynecological surgery, encompassing 45 randomized controlled trials (RCTs) involving a total of 4,120 patients to evaluate 10 distinct types of adhesion barriers.²¹ They conducted a systematic search of relevant databases and exclusively included secondary surgical RCTs for the assessment of pelvic/abdominal adhesions, thereby establishing a robust foundation for analyzing the adhesion prevention potential of these barriers. The study revealed that expanded polytetrafluoroethylene, hyaluronic acid, and modified starch demonstrated the most significant improvements in reducing adhesions.

The central finding of this study reveals that the long-term recurrence rate of endometriosis in the barrier group is markedly lower than that in the control group (15.29% versus 26.38%, $P < 0.001$). This outcome aligns with findings from several prior studies. For instance, systematic reviews and related research conducted by Ahmad et al (encompassing 19 randomized controlled trials with 1,316 participants) and Farag et al (involving 52 studies) have demonstrated that various adhesion barriers can diminish the incidence of postoperative adhesions in gynecological surgeries and enhance pregnancy rates, without inducing directly related adverse events.^{22,23} Nevertheless, in contrast to previous studies that predominantly concentrated on short-term recurrence (within a 2-year span), this study prolonged the follow-up duration to 5 years and verified that the adhesion barrier's suppressive effect on recurrence can persist over an extended period. The plausible mechanism is that the adhesion barrier can create a physical barrier on the surgical site's surface, hindering the adhesion and re-adhesion of endometrial fragments, mitigating pelvic inflammatory responses, and thereby reducing the risk of disease recurrence. Furthermore, adhesion barriers can modulate the local microenvironment within the pelvic cavity, curb the proliferation and invasion of endometriosis lesions, and contribute to preventing recurrence.

Pelvic pain stands as one of the primary clinical manifestations of endometriosis, with its alleviation constituting a pivotal objective in clinical treatment.^{24,25} This study revealed that, at every follow-up time point, the Visual Analogue Scale (VAS) scores for pelvic pain in the barrier group were notably lower than those in the control group, suggesting that adhesive barriers can effectively mitigate pelvic pain over an extended period. This efficacy is intricately linked to the anti-adhesive properties of the adhesive barrier. Postoperative adhesions can induce traction and compression of pelvic organs, thereby precipitating persistent pelvic pain.²⁶ Adhesive barriers can diminish adhesion formation, reduce mechanical irritation to pelvic organs, and consequently alleviate pain.^{27,28} Simultaneously, attenuating the inflammatory response instigated by adhesions may also contribute to pain relief. A prospective randomized placebo-controlled pilot study by Ekin et al, involving patients with deep infiltrating endometriosis (DIE) undergoing laparoscopic surgery, demonstrated that intraoperative application of NCH gel significantly reduced postoperative VAS scores for dysmenorrhea and dyspareunia at both 3 and 6 months, decreased the Endometriosis Health Profile-5 (EHP-5) score, enhanced the physical and mental component summary scores of the 12-Item Short Form Health Survey (SF-12), and improved patients' quality of life.²⁹ Nevertheless, this study further uncovered that the analgesic effect of the adhesion barrier can persist for 4 years or even longer, offering a more comprehensive rationale for the clinical management of chronic pelvic pain stemming from endometriosis.

Multivariate Cox regression analysis revealed that the non-use of adhesion barriers during surgery, r-AFS stages III–IV, and incomplete resection of lesions were independent risk factors for the long-term recurrence of endometriosis. Notably, r-AFS stages III–IV and incomplete lesion resection are widely recognized risk factors for endometriosis recurrence, aligning with findings from the majority of prior studies.^{30–32} This study further corroborates that the application of adhesion barriers serves as a significant protective factor, thereby reminding clinicians to actively consider the intraoperative use of adhesion barriers for patients at high risk of recurrence (eg., those with r-AFS stages III–IV or incomplete lesion resection) to mitigate recurrence risks. Additionally, this study observed that the use of adhesion barriers exhibited favorable safety profiles, with no notable adverse reactions reported during the follow-up period. These

findings are consistent with safety data from previous studies on hyaluronic acid-based adhesion barriers, suggesting that adhesion barriers represent a safe and efficacious clinical intervention.

This study inevitably presents several limitations. Firstly, as a single-center retrospective study, it is inherently prone to selection bias and information bias. The pivotal variable of “adhesion barrier utilization” may be swayed by surgeon preferences or unrecorded patient-specific factors, thereby undermining causal inference. Secondly, being a single-center investigation with samples sourced exclusively from Jingzhou Central Hospital, this study may exhibit certain regional constraints. Consequently, the findings necessitate validation through a larger-scale, multicenter prospective study. Thirdly, this study exclusively employed hyaluronic acid-based adhesion barriers without comparing the efficacy across different types, rendering it impossible to ascertain which type of adhesion barrier demonstrates superior long-term efficacy. Fourthly, the study is devoid of data pertaining to fertility outcomes, such as postoperative pregnancy rates, which constitute a critical concern for patients with endometriosis. Moreover, it lacks validated Quality of Life (QoL) questionnaires, relying solely on VAS scores to evaluate patients’ health status. The administration of postoperative hormonal therapy represents a significant confounding variable for recurrence and pain, which was neither documented nor controlled for in the analysis. Looking ahead, prospective multicenter studies should be undertaken to compare the efficacy of various adhesion barriers and further substantiate their long-term efficacy and safety profiles.

Conclusion

In conclusion, employing adhesion barriers in laparoscopic surgery for endometriosis can markedly decrease the long-term recurrence rate of the condition, effectively mitigate pelvic pain, and demonstrate favorable safety profiles. This approach constitutes an effective strategy for enhancing the long-term prognosis of endometriosis patients. Nevertheless, prior to routine clinical implementation, additional large-scale, multicenter prospective studies are imperative to validate the long-term efficacy and safety. Clinicians may contemplate utilizing adhesion barriers during surgical procedures, tailored to the individual circumstances of patients, particularly those at elevated risk of recurrence, thereby fulfilling the objective of personalized treatment.

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Disclosure

The authors report no conflicts of interest in this work.

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