

Comparison of Postoperative Complications and Perioperative Outcomes Between Endoscopic-Assisted and Open Prosthetic Breast Reconstruction: A Retrospective Study

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AIM: To compare the incidence of complications within 90 days postoperatively and perioperative outcomes between endoscopic-assisted and open prosthetic breast reconstruction.

METHODS: Data from female patients who underwent total mastectomy and prosthetic breast reconstruction from January 2021 to December 2025 were retrospectively collected. A total of 213 patients were included. Patients were divided into an endoscopic-assisted group (endoscopic group) and an open group according to the surgical approach. Propensity score matching (PSM) was performed at a 1:1 ratio to balance baseline covariates. After PSM, 61 patients were in each group, with balanced baseline characteristics. Intraoperative parameters (operative time, blood loss), postoperative recovery indices (postoperative day 1 drainage volume, drainage duration, length of hospital stay, pain visual analogue scale (VAS) score), patient-reported outcomes (BREAST-Q breast satisfaction, aesthetic score), and complications within 90 days postoperatively were compared between the two groups. Depending on normality test results, continuous variables were analyzed using the *t*-test or Mann-Whitney U test, and categorical variables using the χ^2 test or Fisher's exact test.

RESULTS: The endoscopic group had longer implant placement time ($p < 0.001$) and total operative time ($p < 0.001$) than the open group, but less intraoperative blood loss ($p < 0.001$). The endoscopic group showed significantly better outcomes in terms of drainage volume on postoperative day 1, drainage duration, hospital stay, and VAS scores on postoperative days 1 and 3 (all $p < 0.05$). BREAST-Q breast satisfaction ($p = 0.004$), aesthetic score ($p = 0.005$), and good or excellent rate ($p = 0.028$) were higher in the endoscopic group than in the open group. No significant differences were found between the two groups in overall complication rate or any individual complication (all $p > 0.05$).

CONCLUSIONS: After balancing confounders with PSM, endoscopic-assisted prosthetic breast reconstruction was associated with longer operative time than the open approach, but it was associated with lower intraoperative blood loss, faster postoperative recovery, less early pain, and higher patient satisfaction and aesthetic scores, with no significant differences observed in 90-day complications between the two groups. The endoscopic-assisted technique showed favorable perioperative outcomes in this cohort, especially suitable for patients with high demands for rapid rehabilitation and aesthetic results.

Keywords: breast reconstruction; endoscopic surgical procedures; propensity score; postoperative complications

Introduction

Breast cancer is the most common malignancy among women worldwide. According to the 2022 GLOBOCAN statistics, there were approximately 2.3 million new cases of breast cancer and about 660,000 deaths globally, accounting for 11.6% of all new female cancer cases and 6.9% of cancer deaths [1]. With advances in early diagnosis and comprehensive treatment, the long-term survival rate of breast cancer patients has markedly improved, and patients' demands for quality of life after surgery are increas-

ing. Against this background, breast reconstruction after total mastectomy has become an indispensable component of comprehensive breast cancer treatment. Currently, prosthetic breast reconstruction, owing to its relative simplicity, minimal invasiveness, and absence of donor-site morbidity, has become the most widely used breast reconstruction method worldwide. Data from the American Society of Plastic Surgeons show that prosthetic breast reconstruction accounts for nearly 80% of all breast reconstruction procedures [2]. In China, the breast reconstruction rate has risen from 5.3% in 2010 to 16.7% in 2023, with direct-to-implant reconstruction accounting for 73.4% of prosthetic reconstructions in 2023 [3].

Traditional prosthetic breast reconstruction is usually performed through an inframammary fold incision or a radial incision from the original tumor excision, requiring direct incision of the skin and subcutaneous tissue over the breast. Although this open approach is relatively straightforward,

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it has inherent limitations: the incision is made on the breast surface, leading to obvious postoperative scarring; some patients may develop poor wound healing or hypertrophic scarring; direct exposure and compression of the flap and subcutaneous tissues may exacerbate local tissue trauma and increase the risk of postoperative bleeding, exudation, and flap ischemia. Therefore, how to further reduce surgical trauma and optimize incision aesthetics while ensuring satisfactory reconstruction outcomes has been a continuous pursuit of breast and plastic surgeons.

With the expansion of minimally invasive concepts in breast surgery, endoscopic-assisted techniques have been gradually introduced into breast reconstruction. Endoscopic-assisted prosthetic breast reconstruction creates a precise pocket for the prosthesis and inserts the implant through a small axillary incision (usually 4–5 cm) away from the breast, under endoscopic assistance. In recent years, several studies have evaluated the clinical outcomes of endoscopic-assisted prosthetic breast reconstruction. A network meta-analysis published in 2025 that included 10 studies systematically compared the clinical efficacy of robotic nipple-sparing mastectomy (NSM), conventional NSM, and endoscopic-assisted NSM with immediate prosthetic reconstruction, and showed that endoscopic-assisted NSM was superior to conventional NSM in terms of incision length, with a generally acceptable complication profile [4]. Chung et al. [5] proposed a reverse-sequence endoscopic NSM technique that effectively expands the operative field under endoscopy by altering the dissection order; recent studies showed that this technique reduced the overall complication rate of bilateral reconstruction from 32.5% in the open group to 6.6% [6]. Regarding patient-reported outcomes, a study by WANG et al. [7] including 209 patients found that the BREAST-Q breast satisfaction score in the endoscopic-assisted group was significantly higher than that in the lateral axillary incision group, and multivariate regression confirmed that endoscopic-assisted surgery was independently associated with higher breast satisfaction.

However, there remain notable evidence gaps in direct comparisons between endoscopic-assisted and open prosthetic breast reconstruction. First, existing studies are mostly small-sample, single-center retrospective analyses and lack high-quality prospective controlled evidence. Second, endoscopic surgery has a well-recognized learning curve. Zhao et al. [8] analyzed the learning curve for reverse-sequence endoscopic nipple-sparing mastectomy with immediate prepectoral implant reconstruction using the cumulative sum (CUSUM) method and found that after standardized endoscopic training, about 18 cases were required to reach the stable phase of the learning curve, and the Breast-Q score of trained surgeons increased from 66 in the first stage to 84 in the second stage. Failure to account for dynamic changes in surgeon experience over time may bias the assessment of true efficacy of endoscopic surgery. Third, and more importantly, baseline characteristics be-

tween the two groups in retrospective studies often differ significantly – younger age, lower body mass index (BMI), and lower mastectomy specimen weight tend to be associated with patient preference for the endoscopic approach, and these patients inherently have lower risks of complications and better prognoses. Traditional direct comparison methods have difficulty in eliminating the confounding effects of selection bias.

To address the selection bias inherent in retrospective comparisons, this study employed propensity score matching (PSM) to balance baseline covariates between the two groups. Based on a single-center consecutive case series, this study systematically compared intraoperative parameters, postoperative recovery indices, patient-reported outcomes, and the incidence of complications within 90 days postoperatively between the two approaches, aiming to provide evidence-based data from balanced and comparable samples on the perioperative safety, rehabilitative advantages, and aesthetic outcomes of endoscopic-assisted prosthetic breast reconstruction.

Methods

Study Population

This was a single-center retrospective cohort study. Data of female patients who underwent total mastectomy and prosthetic breast reconstruction at the Department of Breast Surgery, Affiliated Hospital of Guangdong Medical University, from January 2021 to December 2025, were consecutively collected. Patients were divided into an endoscopic-assisted prosthetic breast reconstruction group (endoscopic group) and an open prosthetic breast reconstruction group (open group) based on the surgical approach. To reduce selection bias resulting from non-randomized group allocation in this retrospective study, PSM was used to balance baseline characteristics between the two groups at a 1:1 ratio, and the matched cohort served as the primary analysis set. The study protocol was approved by the Ethics Committee of Affiliated Hospital of Guangdong Medical University (Approval No.: KT2026-221-01) and complied with the principles of the Declaration of Helsinki. Written informed consent was obtained from all patients before surgery for the use of their clinical data in research.

Inclusion and Exclusion Criteria

Inclusion criteria: (1) female, aged ≥ 18 years; (2) pathologically confirmed breast malignancy or prophylactic mastectomy due to breast cancer susceptibility gene (BRCA)1/2 pathogenic mutation; (3) underwent skin-sparing or nipple-areola-sparing mastectomy with immediate one-stage implant placement; (4) implant placement plane: prepectoral or subpectoral; (5) complete and available clinical and follow-up data.

Exclusion criteria: (1) history of prior radiotherapy to the ipsilateral breast or chest wall; (2) intraoperative conver-

sion from endoscopic to open approach (none occurred in this study); (3) severe cardiac, hepatic, or renal insufficiency or coagulation disorders; (4) loss to follow-up or missing key outcome data within 90 days postoperatively.

Surgical Methods

All surgeries were performed by the same team of breast surgeons experienced in both endoscopic and open breast reconstruction. Total mastectomy followed standard oncological principles, and axillary lymph node assessment (sentinel lymph node biopsy or axillary lymph node dissection) was performed according to clinical guidelines. All patients underwent immediate, single-stage, direct-to-implant reconstruction after total mastectomy.

Endoscopic-assisted prosthetic breast reconstruction group: The patient was placed in the supine position under general anesthesia. After skin-sparing/nipple-areola-sparing mastectomy, a 4–5 cm incision was made along the axillary crease. A wound protector was inserted through this incision, and the endoscopic system was connected. CO₂ gas was insufflated to maintain a pneumo-dissection pressure of 8–10 mmHg. Under endoscopic visualization, an ultrasonic scalpel or electric hook was used to precisely dissect the subpectoral or prepectoral space. The medial origin of the pectoralis major muscle was managed based on chest wall tension. After pocket preparation, a mesh (titanized polypropylene mesh) was used as needed and sutured to the inferior edge of the pectoralis major muscle and the inframammary fold fascia with barbed sutures under endoscopic monitoring to provide anterior wall support. After meticulous hemostasis, pneumo-dissection was released, and a selected silicone implant (round or anatomical) was placed through the same axillary incision. Two negative-pressure drains (parasternal and axillary) were placed, and the incision was closed in layers. For each patient, the postoperative day 1 drainage volume was calculated as the sum of 24-hour output from all drains. This postoperative day 1 drainage volume, rather than the per-drain output from individual drains, was used for between-group comparisons because it reflects the overall exudative response and tissue trauma in the surgical field, and serves as a key indicator of surgical invasiveness. The total 24-hour drainage volume was recorded, and each drain was removed when its 24-hour output was <30 mL.

Open prosthetic breast reconstruction group: After total mastectomy, an inframammary fold incision or a radial incision (length 5–7 cm) was used. The subpectoral or prepectoral space was dissected under direct vision using electrocautery. The origin of the pectoralis major muscle was managed, or a dual-plane technique was applied. Mesh fixation and implant placement were performed as described above. All patients in this study underwent immediate one-stage direct-to-implant reconstruction. A negative-pressure drain was placed in the parasternal region, and the incision was

closed in layers. The same criterion for drain removal (24-hour output <30 mL) was applied.

Both groups received intravenous first-generation cephalosporin (cefazolin 2 g) 30 minutes before skin incision for infection prophylaxis, which was discontinued within 24 hours postoperatively. Postoperative analgesia was provided via patient-controlled intravenous analgesia (PCIA). The analgesic solution consisted of sufentanil 2 µg/kg, flurbiprofen axetil 100 mg, and tropisetron 5 mg, diluted in 0.9% saline to a total volume of 100 mL. The pump was programmed with a background infusion rate of 2 mL/h, a bolus dose of 2 mL, and a lockout interval of 15 min. Drainage tubes were removed when the 24-hour drainage volume from a single tube was <30 mL. All patients wore a non-underwired elastic compression bra and were advised to limit excessive shoulder movement for 3–4 weeks. All patients in both groups received a standardized postoperative analgesic regimen consisting of PCIA for 48 hours, combined with oral non-steroidal anti-inflammatory drugs (celecoxib 200 mg bid) as baseline analgesia. If the visual analogue scale (VAS) score was ≥4, tramadol 100 mg was administered intramuscularly as rescue analgesia. The analgesic regimen was identical between the two groups.

Data Collection and Outcome Measures

The following data were collected from the electronic medical record system and outpatient follow-up records.

Baseline data: Age, body mass index (BMI), smoking history, history of hypertension, history of diabetes, neoadjuvant chemotherapy, postoperative adjuvant radiotherapy plan, mastectomy specimen weight (g), surgical side, tumor stage (0/I/II/III), extent of resection (skin-sparing/nipple-areola-sparing), implant placement plane (prepectoral/subpectoral), use of mesh, and implant volume (mL).

Primary outcome measure: incidence of surgery-related complications within 90 days postoperatively, including surgical site infection (requiring antibiotic therapy or incision and drainage), hematoma (requiring surgical evacuation or aspiration), seroma (requiring aspiration), flap necrosis (epidermal/full-thickness), nipple-areola complex necrosis, implant exposure or loss (implant removal). All patients in this study underwent unilateral breast reconstruction; therefore, complications were analyzed on a per-patient basis. Complication severity was graded according to the Clavien-Dindo classification. Complication severity was graded according to the Clavien-Dindo classification. Capsular contracture was not included in the 90-day complication assessment, as it is generally considered a medium- to long-term complication.

Secondary perioperative outcome measures: total operative time (min), implant placement time (min, from completion of mastectomy to wound closure after implant placement), estimated intraoperative blood loss (mL), drainage volume

on postoperative day 1 (mL), total duration of drain placement (days), postoperative length of hospital stay (days), unplanned reoperation rate within 90 days, and unplanned readmission rate within 90 days. Intraoperative blood loss was estimated based on the volume recorded in the anesthesia record, with the suction volume adjusted by subtracting the amount of irrigation fluid used during surgery. Pain was assessed using the VAS, with higher scores indicating greater pain. Specially trained nurses guided patients to indicate their current pain level (at rest) on postoperative days 1 and 3; the distance from the zero mark to the patient's mark was measured (cm) and recorded as the VAS score (0–10) [9].

Patient-reported outcomes and aesthetic assessment:

(1) Patient-reported outcomes: At the 6-month postoperative follow-up visit, the BREAST-Q Reconstruction module (version 2.0) [10] was used to assess patient satisfaction with the reconstructed breast. This is a patient-reported outcome measure specifically for breast reconstruction after breast cancer, cross-culturally adapted and validated for reliability and validity. It comprises 10 items, and scores are transformed to a 0–100 scale, with higher scores indicating greater satisfaction. The questionnaire was completed by patients independently in a private room under the guidance of a trained research assistant. Patients were not informed of the study hypothesis or the expected differences between the two surgical approaches during questionnaire administration, and the scoring was completed by independent research assistants who were not involved in the surgical procedures. However, patients could not be completely blinded to their surgical approach because of the inherent difference in incision location between the two techniques.

(2) Aesthetic assessment: At the 6-month postoperative follow-up, anterior, left/right oblique (45°), and lateral photographs of both breasts were taken. Two independent reviewers (one plastic surgeon and one breast surgeon) who were not involved in the surgery performed blinded scoring of overall aesthetics using a 5-point Likert scale: 1 = poor, 2 = fair, 3 = acceptable, 4 = good, 5 = excellent [11]. The mean score of the two reviewers was used as the final aesthetic score, and the proportion of patients with a score ≥ 4 (good or excellent) was recorded. The assessment included breast volume symmetry, inframammary fold position, nipple-areola complex position, and scar appearance.

Statistical Analysis

Statistical analyses were performed using SPSS 26.0 (IBM Corp., Armonk, NY, USA) and R software (version 4.5.2, R Foundation for Statistical Computing, Vienna, Austria) with the MatchIt package (version 4.5.0). All tests were two-sided, and $p < 0.05$ was considered statistically significant. The normality of continuous variable distributions was first assessed using the Shapiro-Wilk test. Normally distributed variables are expressed as mean $\pm$ standard deviation (SD) and were compared using an independent-

samples t -test. Non-normally distributed variables are expressed as median (interquartile range) [Median (Q₁, Q₃)] and were compared using the Mann-Whitney U test. Categorical variables are presented as frequencies and percentages (n, %). Group comparisons were performed using Pearson's χ^2 test or Fisher's exact test (when any expected cell count was < 5). For ordinal categorical variables, between-group comparisons were performed using the Mann-Whitney U test.

Propensity score matching (PSM): The surgical approach was used as the dependent variable, and baseline variables that might clinically affect the choice of approach and prognosis were entered as covariates into a multivariate logistic regression model to calculate the propensity score for each patient. Covariates included age, BMI, smoking history, hypertension history, diabetes history, neoadjuvant chemotherapy, planned adjuvant radiotherapy, mastectomy specimen weight, type of mastectomy (skin-sparing/nipple-areola-sparing), tumor stage, implant placement plane (prepectoral/subpectoral), and mesh use. One-to-one nearest-neighbor matching was performed using a caliper width of 0.05 times the standard deviation of the propensity score. After matching, covariate balance was assessed using the standardized mean difference (SMD), with an SMD < 0.2 indicating good balance between the two groups. Although 1:1 propensity score matching was performed, post-matching comparisons were conducted using independent-samples t -test, Mann-Whitney U test, and χ^2 /Fisher's exact test as exploratory analyses.

Results

Baseline Characteristics Before and After Matching

Before matching, a total of 213 consecutive patients were included, comprising 101 in the endoscopic-assisted prosthetic breast reconstruction group (endoscopic group) and 112 in the open prosthetic breast reconstruction group (open group). No intraoperative conversion from endoscopic to the open approach occurred in this study. There were statistically significant differences between the two groups in age, hypertension, implant plane, mesh use, and tumor stage ($p < 0.05$). Sixty-one patients from the endoscopic group and 61 from the open group were successfully matched. After matching, there were no statistically significant differences in all the above baseline variables between the two groups (all $p > 0.05$), and standardized mean differences (SMDs) were all < 0.2 , indicating good balance in covariate distribution and comparability between groups (Table 1). The reduction in sample size after PSM was primarily attributable to significant pre-matching between-group differences in several baseline covariates before matching (age, hypertension, mesh use, and tumor stage), as well as the application of a caliper width of 0.05 times the standard deviation of the propensity score for 1:1 nearest-neighbor matching to ensure optimal covariate balance.

Table 1. Baseline characteristics before and after PSM.

Variable	Before matching				After matching			
	Open group (N = 112)	Endoscopic group (N = 101)	<i>p</i>	SMD	Open group (N = 61)	Endoscopic group (N = 61)	<i>p</i>	SMD
Age (years), mean ± SD	50.47 ± 8.65	47.31 ± 7.83	0.006	0.384	47.89 ± 8.59	48.39 ± 8.41	0.742	0.060
BMI (kg/m ²), mean ± SD	23.85 ± 2.93	23.73 ± 2.89	0.766	0.041	24.09 ± 2.92	24.13 ± 2.91	0.933	0.015
Smoking history, n (%)								
No	96 (85.7)	89 (88.1)	0.752	0.071	52 (85.2)	52 (85.2)	1.000	<0.001
Yes	16 (14.3)	12 (11.9)			9 (14.8)	9 (14.8)		
Hypertension, n (%)								
No	90 (80.4)	93 (92.1)	0.024	0.345	53 (86.9)	54 (88.5)	1.000	0.050
Yes	22 (19.6)	8 (7.9)			8 (13.1)	7 (11.5)		
Diabetes history, n (%)								
No	103 (92.0)	94 (93.1)	0.964	0.042	58 (95.1)	59 (96.7)	1.000	0.083
Yes	9 (8.0)	7 (6.9)			3 (4.9)	2 (3.3)		
Neoadjuvant chemotherapy, n (%)								
No	82 (73.2)	78 (77.2)	0.605	0.093	46 (75.4)	44 (72.1)	0.837	0.075
Yes	30 (26.8)	23 (22.8)			15 (24.6)	17 (27.9)		
Planned radiotherapy, n (%)								
No	93 (83.0)	78 (77.2)	0.373	0.146	48 (78.7)	48 (78.7)	1.000	<0.001
Yes	19 (17.0)	23 (22.8)			13 (21.3)	13 (21.3)		
Specimen weight (g), mean ± SD	449.73 ± 96.03	442.87 ± 100.66	0.611	0.070	457.15 ± 102.24	440.95 ± 94.76	0.366	0.164
Mastectomy type, n (%)								
Skin-sparing	66 (58.9)	48 (47.5)	0.126	0.230	32 (52.5)	32 (52.5)	1.000	<0.001
NSM	46 (41.1)	53 (52.5)			29 (47.5)	29 (47.5)		
Implant plane, n (%)								
Subpectoral	94 (83.9)	64 (63.4)	<0.001	0.480	46 (75.4)	42 (68.9)	0.545	0.147
Prepectoral	18 (16.1)	37 (36.6)			15 (24.6)	19 (31.1)		
Mesh use, n (%)								
No	96 (85.7)	50 (49.5)	<0.001	0.839	45 (73.8)	42 (68.9)	0.689	0.109
Yes	16 (14.3)	51 (50.5)			16 (26.2)	19 (31.1)		
Tumor stage, n (%)								
0	4 (3.6)	15 (14.9)	0.014	0.454	4 (6.6)	5 (8.2)	0.988	0.066
I	38 (33.9)	37 (36.6)			24 (39.3)	23 (37.7)		
II	48 (42.9)	29 (28.7)			21 (34.4)	21 (34.4)		
III	22 (19.6)	20 (19.8)			12 (19.7)	12 (19.7)		

PSM, propensity score matching; BMI, body mass index; NSM, nipple-sparing mastectomy.

Intraoperative and Surgery-Related Parameters

Total operative time was longer in the endoscopic group than in the open group, with a statistically significant difference ($p < 0.001$). Implant placement time was also significantly longer in the endoscopic group ($p < 0.001$). Intraoperative blood loss was significantly lower in the endoscopic group ($p < 0.001$) (Table 2).

Postoperative Recovery and Pain Scores

Postoperative postoperative day 1 drainage volume, drain duration, and postoperative hospital stay were all lower/shorter in the endoscopic group than in the open group ($p < 0.05$). The resting VAS scores on postoperative

days 1 and 3 were lower in the endoscopic group than in the open group, and the differences were statistically significant ($p < 0.05$) (Table 3).

Patient-Reported Outcomes and Aesthetic Results

The BREAST-Q breast satisfaction score was higher in the endoscopic group than in the open group ($p = 0.004$). The aesthetic score was higher in the endoscopic group than in the open group ($p = 0.005$). The proportion of patients with good or excellent aesthetic outcome (≥ 4 points) was 67.21% in the endoscopic group and 47.54% in the open group, with a statistically significant difference ($p = 0.028$) (Table 4).

Table 2. Comparison of intraoperative and surgery-related parameters between the matched groups.

Variable	Endoscopic group (n = 61)	Open group (n = 61)	Statistic	p value
Total operative time (min), mean $\pm$ SD	190.56 $\pm$ 27.19	145.87 $\pm$ 22.93	$t = 9.81$	<0.001
Implant placement time (min), mean $\pm$ SD	77.82 $\pm$ 13.09	59.16 $\pm$ 12.18	$t = 8.15$	<0.001
Blood loss (mL), median (Q ₁ , Q ₃)	64.00 (48.00, 77.00)	157.00 (117.00, 185.00)	$Z = -8.38$	<0.001

Table 3. Comparison of postoperative recovery and pain scores between matched groups.

Variable	Endoscopic group (n = 61)	Open group (n = 61)	Statistic	p value
Postoperative day 1 drainage volume (mL), median (Q ₁ , Q ₃)	292.00 (236.00, 358.00)	413.00 (349.00, 491.00)	$Z = -5.70$	<0.001
Drainage duration (days), median (Q ₁ , Q ₃)	5.00 (4.00, 6.00)	6.00 (5.00, 7.00)	$Z = -2.76$	0.006
Hospital stay (days), median (Q ₁ , Q ₃)	5.00 (4.00, 6.00)	8.00 (7.00, 10.00)	$Z = -6.87$	<0.001
VAS day 1, median (Q ₁ , Q ₃)	2.00 (1.00, 3.00)	3.00 (2.00, 4.00)	$Z = -3.65$	<0.001
VAS day 3, median (Q ₁ , Q ₃)	1.00 (0.00, 2.00)	2.00 (1.00, 3.00)	$Z = -3.09$	0.002

VAS, visual analogue scale.

Table 4. Comparison of patient-reported outcomes and aesthetic scores between the matched groups.

Variable	Endoscopic group (n = 61)	Open group (n = 61)	Statistic	p value
BREAST-Q breast satisfaction, mean $\pm$ SD	78.03 $\pm$ 10.94	72.23 $\pm$ 10.75	$t = 2.96$	0.004
Aesthetic score (1–5), median (Q ₁ , Q ₃)	4.00 (3.00, 4.00)	3.00 (3.00, 4.00)	$Z = -2.80$	0.005
Good or excellent (score ≥ 4), n (%)			$\chi^2 = 4.83$	0.028
No	20 (32.79)	32 (52.46)		
Yes	41 (67.21)	29 (47.54)		

Postoperative Complications

The overall complication rate within 90 days postoperatively was 19.67% in the endoscopic group and 21.31% in the open group, with no statistically significant difference between groups ($p = 0.823$). Further analysis of each specific complication showed no statistically significant differences between the two groups in terms of surgical site infection, hematoma, seroma, flap necrosis, nipple-areola necrosis, or implant loss (all $p > 0.05$) (Table 5). The unplanned reoperation rate within 90 days was 6.56% (4/61) in the endoscopic group and 4.92% (3/61) in the open group ($p = 1.000$). The unplanned readmission rate was 4.92% (3/61) and 3.28% (2/61), respectively ($p = 1.000$).

Discussion

In this study, we used propensity score matching to compare perioperative outcomes and 90-day complications between endoscopic-assisted and open prosthetic breast reconstruction. Our results show that the two surgical approaches had distinct characteristics: the endoscopic approach was associated with longer total operative time and implant placement time, but also with lower intraoperative blood loss, lower postoperative day 1 drainage volume, shorter drain duration and hospital stay, lower early postoperative VAS pain scores, and higher BREAST-Q breast satisfaction scores and aesthetic scores. The open approach was associated with shorter operative time, with no significant differences in overall or individual complication rates compared with the endoscopic approach. These findings

suggest that the two approaches involve trade-offs in perioperative metrics, and the clinical choice should consider factors such as surgical efficiency, early recovery and aesthetic outcomes.

In our study, both total operative time and implant placement time were longer in the endoscopic group than in the open group. This difference has been observed in most previous studies of endoscopic breast surgery. Endoscopic surgery requires additional time for setting up and debugging the endoscopic system, maintaining stable pneumodissection pressure, performing precise pocket dissection and hemostasis in a confined workspace, and adapting to depth perception in a two-dimensional view. For the open group, the direct-vision approach is more straightforward and does not require these additional steps, thereby resulting in a shorter operative time. In centers where minimizing anesthesia time or maximizing operating room turnover is a priority, the open approach may still hold certain advantages. Notably, several studies have shown that endoscopic operative time can gradually decrease with accumulating surgeon experience. Zhao et al. [8] analyzed the learning curve of reverse-sequence endoscopic nipple-sparing mastectomy with immediate prepectoral implant reconstruction using the CUSUM method and reported that operative time reached a stable phase after approximately 18 cases. Grande et al. [12] also found that operative time for single-port insufflation endoscopic NSM with immediate implant reconstruction improved significantly from the 13th case onward. Therefore, the longer operative time observed in our endoscopic group may be partly attributable to

Table 5. Comparison of postoperative complications within 90 days between the matched groups.

Variables	Endoscopic group (n = 61)	Open group (n = 61)	Statistic	p value
Infection, n (%)				0.361
No	57 (93.44)	60 (98.36)		
Yes	4 (6.56)	1 (1.64)		
Hematoma, n (%)				1.000
No	59 (96.72)	58 (95.08)		
Yes	2 (3.28)	3 (4.92)		
Seroma, n (%)				0.166
No	59 (96.72)	54 (88.52)		
Yes	2 (3.28)	7 (11.48)		
Flap necrosis, n (%)				1.000
No	59 (96.72)	60 (98.36)		
Yes	2 (3.28)	1 (1.64)		
Nipple necrosis, n (%)				1.000
No	60 (98.36)	60 (98.36)		
Yes	1 (1.64)	1 (1.64)		
Implant loss, n (%)				0.242
No	58 (95.08)	61 (100.00)		
Yes	3 (4.92)	0 (0.00)		
Overall complications, n (%)			$\chi^2 = 0.05$	0.823
No	49 (80.33)	48 (78.69)		
Yes	12 (19.67)	13 (21.31)		
Unplanned reoperation, n (%)				1.000
No	57 (93.44)	58 (95.08)		
Yes	4 (6.56)	3 (4.92)		
Unplanned readmission, n (%)				1.000
No	58 (95.08)	59 (96.72)		
Yes	3 (4.92)	2 (3.28)		

Note: Overall complications were calculated based on the number of patients who experienced at least one complication. The sum of individual complication counts may exceed the overall total because some patients experienced multiple complications.

the learning curve effect; as case numbers accumulate, the gap in operative time between the two groups may narrow.

The lower intraoperative blood loss in the endoscopic group compared to the open group is likely related to the magnified endoscopic view, which allows better visualization of blood vessels and more precise hemostasis with the ultrasonic scalpel [13]. In open surgery, even with meticulous hemostasis, the larger incision and more extensive flap dissection may still result in more diffuse oozing. In our study, the endoscopic group also had lower postoperative day 1 drainage volume, shorter drainage duration, and a shorter hospital stay than the open group, suggesting that the endoscopic approach causes less local tissue trauma and a lower postoperative exudative response [14]. A study by Kim et al. [14] also found that patients undergoing endoscopic-assisted latissimus dorsi flap reconstruction had a shorter hospital stay than those undergoing open surgery. Regarding pain control, the lower VAS scores in the endoscopic group may be attributed to the small axillary incision that avoids a breast surface incision and causes less injury to the intercostal nerve and pectoralis major muscle during re-

traction [15,16]. For patients who prioritize early recovery and postoperative comfort, the endoscopic approach may be more attractive.

There were no statistically significant differences between the two groups in the overall complication rates or in the rates of individual complications (surgical site infection, hematoma, seroma, flap necrosis, nipple-areola necrosis, implant loss) within 90 days, with no significant differences in short-term complications observed between the two groups in this cohort. A network meta-analysis including 10 studies also showed no statistically significant difference in overall complications between endoscopic-assisted NSM and conventional NSM [4]. Another meta-analysis focusing on tissue expander placement reported lower complication rates in the endoscopic-assisted group than in the open group [17]. However, that study involved tissue expander placement rather than direct-to-implant reconstruction, and there was heterogeneity among the included studies in terms of implant plane, mesh use, and other factors, which may have affected comparability of results. In our study, the seroma rate was numerically higher in the open

group than in the endoscopic group, although the difference was not statistically significant. This trend is consistent with the observation that endoscopic visualization allows more thorough hemostasis and reduced dead space. Seroma is reported to be one of the most common complications after prosthetic breast reconstruction, and its accumulation may increase the risk of periprosthetic infection and implant loss [18].

Patient-reported outcomes (PROs) are an important dimension in evaluating the success of breast reconstruction. In our study, the endoscopic group had higher BREAST-Q breast satisfaction scores and aesthetic scores than the open group. An observational study in a Chinese population also found that endoscopic-assisted surgery had the highest BREAST-Q satisfaction score among various incision techniques, and Wang et al. [7] reported in the full text that endoscopic-assisted surgery was independently associated with higher breast satisfaction scores in multivariate regression analysis. The concealed axillary incision avoids a visible scar on the breast surface, providing clear psychological benefits for patients who place a high value on appearance. Even with optimal healing, open surgery leaves a visible scar at the inframammary fold or the original tumor site, which may negatively affect body image in some patients. Nevertheless, open surgery is technically mature, has a short learning curve, and is widely applicable; it remains a reasonable option for patients who are less concerned about scarring or who wish to minimize operative time.

In summary, given that short-term complication risks are comparable between the two approaches and that each has distinct perioperative characteristics, clinical decision-making should be primarily based on individualized patient needs and the surgeon's technical proficiency.

This study has several limitations. It is a single-center retrospective study; although PSM was used, unmeasured confounding may remain. The sample size was relatively small, resulting in limited statistical power for detecting low-incidence complications. Follow-up was limited to 90 days, so long-term outcomes, including capsular contracture and implant survival, cannot be assessed. Although aesthetic outcomes were assessed by independent reviewers blinded to the surgical approach, patient-reported outcomes (BREAST-Q) could not be fully blinded because patients were aware of their incision location, and information bias may exist. Future multicenter prospective studies or randomized controlled trials with extended follow-up and inclusion of health economic indices are needed to further validate the long-term value of endoscopic-assisted techniques. In addition, factors such as type of axillary surgery, year of surgery, and the surgeon's learning curve stage were not included in the PSM model and may have introduced residual confounding. The relatively early stage of the endoscopic technique learning curve at our institution may have affected operative time and perioperative outcomes. The matched data were analyzed using methods for inde-

pendent samples, which may not fully account for the paired structure after matching.

Conclusions

After balancing baseline confounders with propensity score matching, endoscopic-assisted prosthetic breast reconstruction offers advantages in reduced blood loss, faster recovery, less early pain, and better aesthetic outcomes compared with the open approach, albeit with longer operative time. Importantly, the two approaches showed similar observed 90-day complication rates, with no significant differences in overall or individual complication rates. In centers with appropriate endoscopic expertise, endoscopic-assisted prosthetic breast reconstruction is a safe and feasible minimally invasive option. Long-term outcomes still require further confirmation through longer follow-up and larger sample sizes.

Availability of Data and Materials

The data analyzed are available from the corresponding author upon reasonable request.

Author Contributions

BYH and YQZ designed the research study. YQZ, JLL and LMZ performed the research. ZDC and BYH analyzed the data. BYH drafted the article. All authors have been involved in revising the manuscript critically for important intellectual content. All authors gave final approval of the version to be published. All authors have participated sufficiently in the work to take public responsibility for appropriate portions of the content and agreed to be accountable for all aspects of the work in ensuring that questions related to its accuracy or integrity.

Ethics Approval and Consent to Participate

The study protocol was approved by the Ethics Committee of Affiliated Hospital of Guangdong Medical University (Approval No.: KT2026-221-01) and complied with the principles of the Declaration of Helsinki. Written informed consent was obtained from all patients before surgery for the use of their clinical data in research.

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Conflict of Interest

The authors declare no conflict of interest.

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