Comparison of Efficacy and Safety of Endoscopic Breast-Conserving Surgery Versus Conventional Breast-Conserving Surgery in Elderly Patients With Breast Cancer: Insights From a Single-Center Retrospective Analysis

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AIM: Breast-conserving surgery (BCS) has been increasingly favored by elderly breast cancer patients to preserve their quality of life. This study compares the efficacy and safety of endoscopic versus conventional BCS in elderly patients, focusing on operative and aesthetic outcomes.

METHODS: A retrospective analysis was conducted on 261 elderly breast cancer patients (age $\geq$70) treated from January 2020 to January 2022. Patients were divided into endoscopic (n = 126) and conventional (n = 135) BCS groups. Surgical observations, complications, immune cell changes, adipokine levels, and survival rates were evaluated. Statistical analyses were performed using SPSS software.

RESULTS: Compared to the conventional BCS group, the endoscopic BCS group had significantly lower intraoperative blood loss (12.82 vs. 128.29 mL; $p < 0.001$), reduced hospitalization costs (13,289.74 vs. 16,032.41 Yuan; 1 Chinese Yuan $\approx$ 0.1385 US Dollars, $p < 0.001$), and shorter drainage duration ($p = 0.002$). The endoscopic BCS group reported superior aesthetic outcomes (66.67% rated as excellent vs. 50.37%; $p = 0.047$) and fewer surgical complications compared to the conventional BCS group, including lower rates of axillary pain, numbness, and arm swelling ($p = 0.002$, $p = 0.002$, and $p = 0.008$, respectively). No significant differences were observed in perioperative immune cell markers, adipokine levels, or survival outcomes between the groups.

CONCLUSIONS: Endoscopic BCS offers advantages in reducing operative morbidity and enhancing aesthetic outcomes without compromising oncological safety for elderly patients.

Keywords: endoscopic breast-conserving surgery; elderly breast cancer; aesthetic outcomes; surgical complications; operative morbidity; oncological safety

Introduction

Breast cancer remains one of the most prevalent malignancies affecting women worldwide, with an increasing incidence observed in the elderly population [1,2]. Due to advancements in early detection and treatment modalities, breast conservation has emerged as a preferred choice over mastectomy for many patients, aiming to achieve oncological safety while preserving quality of life. The standard breast-conserving surgery (BCS) involves the wide local excision of the tumor along with a margin of healthy tissue, followed by adjuvant therapy, which typically includes radiotherapy and, in some cases, chemotherapy or hormone treatments [3–5]. However, as life expectancy continues to rise, a growing number of elderly patients with breast cancer require surgical approaches that not only achieve effective cancer control but also minimize treatment-associated morbidity [6].

In recent years, endoscopic techniques have been introduced as minimally invasive alternatives to conventional surgical methods across a variety of medical disciplines, with their application in BCS drawing particular interest. Endoscopic breast surgery facilitates the magnified visualization of surgical fields, potentially offering benefits in terms of precision, reduced tissue trauma, and improved aesthetic outcomes. Such advancements were particularly appealing in the context of breast cancer, where the aesthetic result was a pivotal component of patient satisfaction and overall quality of life post-treatment [7–9].

Despite these potential benefits, the application of endoscopic techniques in breast cancer surgery for elderly patients was still met with skepticism, primarily due to concerns regarding the adequacy of oncological resection and the potential for increased surgical complications. There was a paucity of rigorous data evaluating the efficacy and safety of endoscopic BCS specifically in the elderly, who often present with comorbidities that could complicate surgical interventions. Moreover, while aesthetic outcomes

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were undeniably important, the primary objective is to achieve the eradication of cancer and acceptable survival outcomes.

This uncertainty regarding the efficacy and safety reflects a broader, ongoing debate within the surgical oncology community concerning the role of advanced surgical techniques in improving patient-centric outcomes without compromising the fundamental principles of cancer surgery. Our study aims to contribute to this discourse by presenting a comprehensive comparison of endoscopic versus conventional breast-conserving approaches based on a retrospective analysis carried out at a single institution.

Materials and Methods

Study Design

A retrospective analysis was conducted on 261 breast cancer patients treated at Ningbo No.2 Hospital between January 2020 and January 2022. Data collected from medical records included patient demographics, types of surgery performed, operative observations, complications, survival times, aesthetic outcomes, perioperative changes in immune cells, and variations in serum leptin and adiponectin levels. This study exclusively utilized anonymized patient data with no risk or impact on patient care. Therefore, informed consent was waived. This waiver complied with regulatory and ethical standards for retrospective research.

Inclusion and Exclusion Criteria

Inclusion criteria of this study are as follows: (1) Elderly women aged 70 years or older [10]; (2) Patients with a maximum tumor diameter of 3 cm, which ensures adequate breast volume and contour post-surgery; (3) Patients with tumor not involving the nipple or areola; (4) Patients with no multifocal or multi-quadrant lesions; (5) Patients who are able to undergo postoperative radiotherapy and chemotherapy [11]; (6) Patients showing no evidence of metastasis in clinical examinations or ultrasound; and (7) Patients with complete medical records and who regularly attend follow-up.

Individuals with the following characteristics were excluded from this study: (1) Widespread or diffusely distributed malignant calcifications [12]; (2) Stage T4 breast cancer, including tumors invading the skin, chest wall, or inflammatory breast cancer; (3) History of previous breast surgery; (4) Active connective tissue diseases involving the skin, particularly scleroderma and lupus erythematosus [13]; (5) Cognitive or mental disorders; and (6) Inability to cooperate within the study, poor patient compliance, or communication difficulties.

Grouping Criteria and Treatment Approach

Based on the treatment method, 261 patients were divided into two groups: the endoscopic BCS group (n = 126) and the conventional BCS group (n = 135).

Surgical Methods

Endoscopic BCS Group: For wide excision of the primary lesion, pre-incision lines were marked according to the requirements of breast-conserving radical mastectomy. The incision was centered on the original biopsy site or over the tumor, with the subcutaneous fat layer appropriately preserved. Endoscopic assistance was used at a distance from the incision, utilizing a wide retractor to create an operational space. An electrocautery or electrical hook was used to separate tissues until the breast segment containing the tumor, the overlying skin, and the underlying pectoral fascia were completely excised. Normal breast tissue at least 1 cm from the tumor edge was sampled for intraoperative frozen pathology to ensure negative margins. For Endoscopy-assisted axillary lymph node dissection, a fat-dissolving solution was injected in multiple layers at the axilla. After 15 minutes, a 1 cm incision was made at the intersection of the mid-axillary line and the nipple horizontal line to insert a suction head and aspirate axillary fat. Post-liposuction, a 10 mm trocar was inserted and secured through the liposuction hole to accommodate Endoscopy. Gas was introduced to maintain pressure. Two 5-mm trocars were then placed and fixed at the outer edge of the pectoralis major and the anterior edge of the latissimus dorsi, respectively, for insertion of separating forceps and electric scissors. Tissue dissection proceeded from the lateral edge of the pectoralis major to behind the pectoralis minor, towards the axillary apex, to remove type 2 lymphoid fat tissue and the intermuscular space of the pectoralis major and minor (Rotter's nodes). Dissection then continued in an outward and downward trajectory, along the axillary vein, to remove type 1 lymphoid fat tissue, completing the axillary lymph node dissection.

Conventional BCS Group: The primary lesion was widely excised using the same incision design as in the endoscopic BCS group, with the breast segment containing the tumor, the overlying skin, and the underlying pectoral fascia being directly removed. Normal breast tissue at least 1 cm from the tumor edge was sampled for intraoperative frozen pathology to ensure negative margins. Axillary lymph node dissection involved an additional incision along the axillary fold on the affected side to remove type 1 and 2 lymphoid fat tissue and the intermuscular space of the pectoralis major and minor (Rotter's nodes), completing the axillary dissection.

All surgeons who performed surgeries for patients in this study have undergone rigorous certification processes, which entail review of $\geq$50 supervised cases and competency assessments. Such certification is to minimize the interference with the surgical results caused by different surgical methods or insufficient proficiency of the surgeons.

Postoperative Treatment

Postoperative care followed a standardized protocol, including: (1) Prophylactic antibiotics for 24 hours; (2) Early

mobilization (within 24 hours); (3) Drain removal when output <30 mL/day; and (4) Adjuvant therapy initiation within 4 weeks. All patients receive whole-breast radiotherapy (WBRT) to reduce the risk of local recurrence, typically at a dose of 45–50 Gray (Gy) delivered in 25–28 fractions. For human epidermal growth factor receptor 2 (HER2)-positive patients, standard adjuvant trastuzumab (Approval Number of Drug by the National Medical Products Administration: SJ20181016, Genentech Inc., Hillsboro, OR, USA) was administered intravenously (IV) every 3 weeks for 1 year. For HER2-negative patients, the Taxotere, Adriamycin and Cyclophosphamide (TAC) chemotherapy regimen was used: docetaxel (Approval Number of Drug by the National Medical Products Administration: H20080366, Jiangsu Hengrui Pharmaceutical Co., Ltd, Lianyungang, China) 75 mg/m^2 IV on day 1; doxorubicin (doxorubicin hydrochloride liposome, Approval Number of Drug by the National Medical Products Administration: H20234166, Zhejiang Haizheng Pharmaceutical Co., Ltd, Hangzhou, China) 50 mg/m^2 IV on day 1; and cyclophosphamide (Approval Number of Drug by the National Medical Products Administration: H32020857, Jiangsu Hengrui Pharmaceutical Co., Ltd, Lianyungang, China) 500 mg/m^2 IV on day 1. This cycle was repeated every 21 days for a total of 6 cycles, with Granulocyte Colony-Stimulating Factor (G-CSF) (Efbemalenograstim alfa Injection, Approval Number of Drug by the National Medical Products Administration: S20230026, Yiyi Biopharmaceutical Co., Ltd, Beijing, China) being administered in all cycles. Aromatase inhibitors were optional, depending on patients' financial circumstances [14].

Baseline Data

Patient data were retrieved from the medical record system, encompassing demographic characteristics such as age, body mass index (BMI), smoking history, alcohol consumption, education level, marital status, and chronic diseases, as well as pathological data and information on tumor progression.

The patients' general health status and treatment tolerance, based on their physical activity, were evaluated using the Eastern Cooperative Oncology Group (ECOG) performance status scale [15]. This scale consists of six levels: 0—fully active with no activity restrictions relative to pre-disease status; 1—ambulatory and capable of light physical activities, such as housework or office work, but unable to perform strenuous activities; 2—ambulatory and self-sufficient, but unable to work, spending more than half of waking hours active; 3—limited self-care, mostly confined to bed or chair for more than half of waking hours; 4—completely disabled, confined to bed or chair, unable to care for oneself; and 5—deceased. Cohen's κ for this scale was 0.486 [15].

Post-operative pathological data included pathological type, tumor-node-metastasis (TNM) stage, estrogen receptor (ER) status, progesterone receptor (PR) status, HER2 status, and axillary lymph node metastasis presence. For cases with borderline HER2 immunohistochemistry (IHC) results (2+), fluorescence *in situ* hybridization (FISH) was employed to determine HER2 positivity [14].

Tumor progression was assessed using the TNM staging system, an internationally accepted method for classifying tumor advancement, where higher stages represent more advanced diseases. Tumor (T) indicates the size and extent of the primary tumor, graded as T1, T2, T3, or T4, with higher numbers indicating larger tumors and greater invasion. Node (N) reflects the involvement of regional lymph nodes, categorized as N0, N1, N2, or N3, with higher numbers indicating more extensive lymph node involvement. Metastasis (M) specifies the presence of distant metastasis, with M0 representing no metastasis and M1 indicating its presence [16].

Operative Observation Indicators and Complications

Operative observation indicators, including intraoperative blood loss, duration of the operation, number of lymph nodes harvested, drainage volume, drainage duration, and hospitalization costs, were recorded. Statistics on the incidence of surgical complications were also gathered, focusing on axillary pain, numbness or paresthesia, and arm swelling.

Survival Time

The final cohort of 261 patients was followed for a median duration of 40 months, with a range of 36 to 60 months. Patients were followed up every 3–4 months via outpatient visits or telephone interviews. Follow-up assessments included: (1) Physical examination; (2) Serum tumor markers (carcinoembryonic antigen [CEA], carbohydrate antigen 15-3 [CA15-3]); (3) Bilateral mammography and ultrasonography; (4) Annual chest/abdominal computed tomography (CT) or positron emission tomography-computed tomography (PET-CT); and (5) Bone scintigraphy if clinically indicated. Disease recurrence was defined as radiographic evidence of local-regional recurrence or distant metastasis. Overall survival (OS) was calculated from the date of surgery to death from any cause. Disease-free survival (DFS) was defined as the time from surgery to the first documented recurrence (local, regional, or distant) or death without recurrence. Patients alive without recurrence were censored at last follow-up. Survival curves were constructed using the Kaplan–Meier method and compared with the log-rank test. The cumulative incidence of recurrence was calculated considering death as a competing risk.

Evaluation of Aesthetic Outcomes

Three-Dimensional (3D) imaging system was used for auxiliary evaluation. The patient was placed in a standardized upright position with their arms extended at a 90° angle. Postoperative 3D breast images were collected using a

structured light 3D scanner (EV.30.78980037, Artec Eva, Artec Group, Luxembourg City, Luxembourg). A validated 3D morphometric analysis software (3D Body Scanning Systems I, 3dMD Ltd, Atlanta, GA, USA) was used to quantify the following parameters: the ratio of operated to contralateral breast volume, Euclidean distance between corresponding surface points on both breasts, and scarring visibility index. The above data were collected for the evaluation of aesthetic outcomes in accordance with the criteria established by the Boston Harvard Joint Center for Radiation Therapy (JCRT). The criteria are as follows: I—Excellent, indicating that the breast on the affected side closely resembles the healthy side; II—Good, indicating minor differences between the affected and healthy breasts; III—Fair, signifying that the appearance of the affected side was noticeably inferior to that of the healthy side; and IV—Poor, denoting severe complications in the affected breast, such as significant deformation or nipple necrosis [17].

Comparison of Safety

Blood was collected from patients one day prior to and one day after surgery. Peripheral blood mononuclear cells (PBMCs) were isolated. Immune cell subsets were analyzed by flow cytometry (CytoFLEX, Beckman Coulter, Brea, CA, USA), including Natural killer cells (NK cells) (Cluster of Differentiation [CD]3^-, $CD16^+$, $CD56^+$), $CD4^+$ T cells ($CD3^+$, $CD4^+$), $CD8^+$ T cells ($CD3^+$, $CD8^+$), and peripheral blood regulatory T cells (Treg cells) ($CD4^+$, $CD25^+$, and forkhead box protein 3 $[Foxp3]^+$). Data acquisition and analysis were performed using CytExpert software (version 2.3, Beckman Coulter, Brea, CA, USA). Absolute cell counts were calculated using counting beads.

The remaining samples were centrifuged at 400 $\times g$ for 10 minutes to separate the serum, which was then transferred to a freezing tube, labeled, and stored at –80 °C. Serum leptin and adiponectin levels were measured using the Leptin Human Instant Enzyme-Linked Immunosorbent Assay (ELISA) Kit and Adiponectin Human ELISA Kit (both from eBioscience, San Diego, CA, USA), respectively, in accordance with the manufacturer's instructions.

Statistical Analysis

Data analysis was performed using SPSS software version 29.0 (SPSS Inc., Chicago, IL, USA). Categorical data are expressed as count (percentage) and were analyzed using the chi-square test. For sample sizes of 40 or more with a theoretical frequency (T) of 5 or greater, the basic chi-square test formula was applied, with the test statistic denoted by χ^2. When the sample size was 40 or more but the theoretical frequency was between 1 and 5, the chi-square test was adjusted using a correction formula. For sample sizes less than 40 or theoretical frequencies less than 1, Fisher's exact test was used for statistical analysis. Continuous variables were initially assessed for normality using the Shapiro–Wilk test. Normally distributed data are expressed as mean ± standard deviation and were analyzed using *t*-test. A *p*-value of less than 0.05 was considered statistically significant.

Results

Baseline Characteristics

No statistically significant differences in multiple demographic indicators were observed between the endoscopic BCS group (n = 126) and the conventional BCS group (n = 135). The age distribution was similar, with 68.25% of patients aged 70–75 in the endoscopic group compared to 71.85% in the conventional group (p = 0.526) (Table 1). There was also no significant difference in ethnicity (p = 0.989), with the Han ethnicity being the majority. The mean BMI was comparable between groups (endoscopic: 24.67 ± 2.95 vs. conventional: 24.62 ± 2.87; p = 0.899). Performance status, smoking and drinking histories, and the prevalence of hypertension and diabetes showed no significant variation between groups. Educational level and marital status were also similar, with p-values of 0.809 and 0.229, respectively. Histologic type, tumor location, surgical site, tumor grade distributions and TNM staging were analogous, and no differences were found in HER2-positive (p = 0.501), ER-positive (p = 0.965), and PR-positive (p = 0.631) statuses. Thus, the groups were well-matched in terms of baseline characteristics.

Operative Observation Indicators

Intraoperative blood loss was substantially lower in the endoscopic BCS group, averaging 12.82 ± 5.46 mL, compared to 128.29 ± 52.82 mL in the conventional BCS group ($p < 0.001$) (Fig. 1). Similarly, hospitalization expenses were significantly reduced in the endoscopic BCS group, averaging 13,289.74 ± 2240.55 Yuan, versus 16,032.41 ± 2356.52 Yuan (1 Chinese Yuan ≈ 0.1385 US Dollars) in the conventional BCS group ($p < 0.001$). Patients in the endoscopic BCS group experienced a shorter drainage duration, averaging 4.64 ± 1.29 days compared to 5.09 ± 1.01 days in the conventional BCS group (p = 0.002), and lesser drainage flow was observed (130.91 ± 39.22 mL vs. 142.29 ± 36.92 mL, p = 0.016). No statistically significant differences were found in operative time, which was 77.23 ± 18.65 minutes for the endoscopic BCS group and 82.12 ± 21.98 minutes for the conventional BCS group (p = 0.550), or in the number of lymph nodes harvested (16.68 ± 4.38 vs. 17.65 ± 5.38, p = 0.112). These results suggest that endoscopic surgery may offer advantages in terms of reduced blood loss, shorter drainage duration, and lower cost without increasing operative time or compromising surgical outcomes.

Perioperative Immune Cell Changes

NK cell counts remained similar between the endoscopic and conventional BCS groups both one day before (endo-

Table 1. Comparison of demographic characteristics between the two groups.

Indicators	Endoscopic BCS group (n = 126)	Conventional BCS group (n = 135)	t/χ^2	p
Age (years)			0.403	0.526
70–75	86 (68.25%)	97 (71.85%)		
≥75	40 (31.75%)	38 (28.15%)		
Ethnicity (Han/other)	113 (89.68%)/13 (10.32%)	121 (89.63%)/14 (10.37%)	0	0.989
BMI (kg/m^2)	24.67 ± 2.95	24.62 ± 2.87	0.128	0.899
ECOG performance status (0/1)	96 (76.19%)/30 (23.81%)	107 (79.26%)/28 (20.74%)	0.355	0.551
Smoking history (yes/no)	6 (4.76%)/120 (95.24%)	8 (5.93%)/127 (94.07%)	0.174	0.677
Drinking history (yes/no)	21 (16.67%)/105 (83.33%)	25 (18.52%)/110 (81.48%)	0.154	0.695
Hypertension (yes/no)	38 (30.16%)/88 (69.84%)	46 (34.07%)/89 (65.93%)	0.458	0.499
Diabetes (yes/no)	31 (24.6%)/95 (75.4%)	39 (28.89%)/96 (71.11%)	0.610	0.435
Educational level (high school or below/college or above)	83 (65.87%)/43 (34.13%)	87 (64.44%)/48 (35.56%)	0.059	0.809
Marital status (married/unmarried)	96 (76.19%)/30 (23.81%)	111 (82.22%)/24 (17.78%)	1.445	0.229
Histologic type			0.866	0.649
Invasive ductal	85 (67.46%)	95 (70.37%)		
Invasive lobular	19 (15.08%)	22 (16.3%)		
Other	22 (17.46%)	18 (13.33%)		
Surgical site			0.867	0.352
Right side	59 (46.83%)	71 (52.59%)		
Left side	67 (53.17%)	64 (47.41%)		
Tumor location			0.320	0.988
Upper outer quadrant	76 (60.32%)	81 (60%)		
Upper inner quadrant	18 (14.29%)	20 (14.81%)		
Central area	15 (11.9%)	16 (11.85%)		
Lower outer quadrant	11 (8.73%)	10 (7.41%)		
Lower inner quadrant	6 (4.76%)	8 (5.93%)		
Tumor grade			1.276	0.528
I	35 (27.78%)	30 (22.22%)		
II	65 (51.59%)	78 (57.78%)		
III	26 (20.63%)	27 (20%)		
TNM stage			0.208	0.901
TisN0M0	26 (20.63%)	31 (22.96%)		
T1-2N0M0	71 (56.35%)	74 (54.81%)		
T1-2N1M0	29 (23.02%)	30 (22.22%)		
Pathological status				
HER2-positve	22 (17.46%)	28 (20.74%)	0.453	0.501
ER-positive	79 (62.7%)	85 (62.96%)	0.002	0.965
PR-positive	70 (55.56%)	71 (52.59%)	0.230	0.631

BCS, breast-conserving surgery; BMI, body mass index; ECOG, Eastern Cooperative Oncology Group; ER, estrogen receptor; HER2, human epidermal growth factor receptor 2; PR, progesterone receptor; TNM, tumor-node-metastasis; T, Tumor; N, Node; M, Metastasis.

scopic: 18.01 ± 2.67 vs. conventional: 17.94 ± 2.62; p = 0.824) and one day after surgery (endoscopic: 17.36 ± 2.87 vs. conventional: 17.35 ± 2.93; p = 0.984) (Table 2). CD4$^+$ T cell levels showed no significant change, measured at 37.54 ± 7.07 in the endoscopic BCS group and 37.85 ± 7.54 in the conventional BCS group one day before operation (p = 0.738), and similarly postoperatively at 35.49 ± 9.39 and 35.89 ± 8.79, respectively (p = 0.722). Treg cell levels were also comparable, with no significant differences pre- (p = 0.185) or post-operation (p = 0.216). CD8$^+$ T cell counts did not differ significantly between groups before (endoscopic: 24.07 ± 2.73 vs. conventional: 24.28 ± 2.89; p = 0.544) or after surgery (endoscopic: 23.79 ± 2.62 vs. conventional: 24.14 ± 2.64; p = 0.279). These findings indicate that both surgical approaches have a similar impact on perioperative immune cell changes in elderly patients with breast cancer. No significant differences in postoperative cytokine levels (e.g., Interleukin-6 [IL-6], Tumor Necrosis Factor-alpha [TNF-α]) were detected between groups (data not shown), supporting the hypothesis that surgical invasiveness, rather than systemic immunity, drives observed differences.

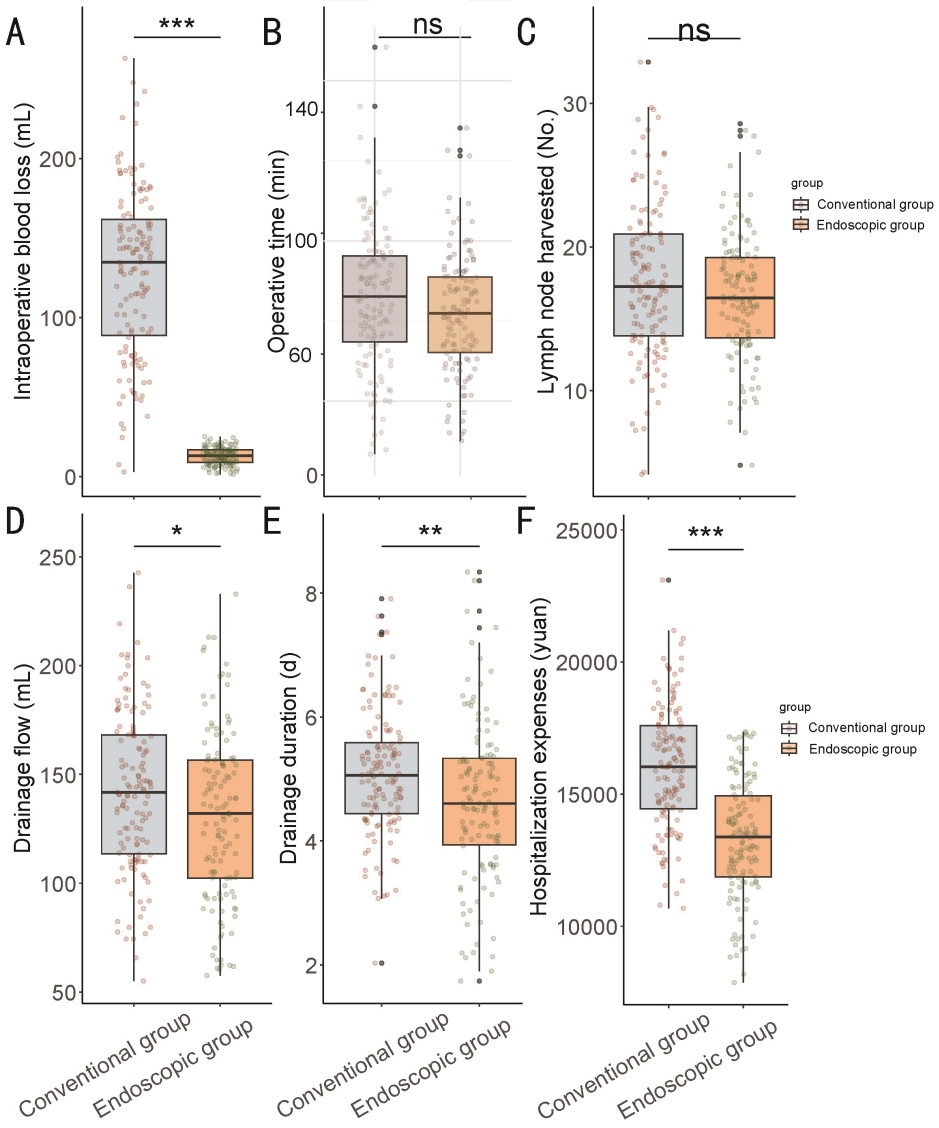

Fig. 1. Comparison of operative observation indicators between endoscopic and conventional breast-conserving surgery groups. (A) Intraoperative blood loss; (B) Operative time; (C) Lymph node harvested; (D) Drainage flow; (E) Drainage duration; (F) Hospitalization expenses. ns: no statistically significant difference; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$. The charts were created with the R software package 3.0.2. (Free Software Foundation, Inc., Boston, MA, USA).

Adipokines

Serum leptin levels measured one day before surgery were 132.57 ± 19.09 in the endoscopic BCS group and 128.62 ± 21.58 in the conventional BCS group ($p = 0.119$) (Fig. 2). Postoperative leptin levels also showed no significant difference, with values of 122.68 ± 28.35 for the endoscopic BCS group and 118.70 ± 22.05 for the conventional BCS group ($p = 0.208$). Similarly, serum adiponectin levels were comparable between the two groups, both preoperatively (endoscopic: 0.99 ± 0.12 vs. conventional: 1.01 ± 0.14; $p = 0.176$) and postoperatively (endoscopic: 0.69 ± 0.09 vs. conventional: 0.71 ± 0.15; $p = 0.211$). These results suggest that the type of surgery does not significantly impact changes in adipokine levels in elderly patients with breast cancer.

Evaluation of Aesthetic Outcomes

In the endoscopic BCS group, 66.67% of patients rated the aesthetic outcome as grade I, compared to 50.37% in the conventional BCS group, demonstrating a statistically significant difference ($p = 0.047$) (Table 3). Additionally, the distribution across other aesthetic grades indicated a tendency towards better aesthetic satisfaction with the endoscopic approach, with fewer patients rating their results as grades III (7.94% vs. 15.56%) or IV (1.59% vs. 2.96%). These findings suggest that endoscopic surgery may provide superior aesthetic outcomes for elderly patients undergoing BCS.

Table 2. Comparison of perioperative immune cell changes between the two groups.

Indicators		Endoscopic BCS group (n = 126)	Conventional BCS group (n = 135)	t	p
NK cells	1 day before operation	18.01 ± 2.67	17.94 ± 2.62	0.223	0.824
	1 day after operation	17.36 ± 2.87	17.35 ± 2.93	0.020	0.984
$CD4^+$ T cells	1 day before operation	37.54 ± 7.07	37.85 ± 7.54	0.335	0.738
	1 day after operation	35.49 ± 9.39	35.89 ± 8.79	0.356	0.722
Treg cells	1 day before operation	2.72 ± 0.91	2.87 ± 0.92	1.328	0.185
	1 day after operation	2.69 ± 0.98	2.84 ± 0.89	1.241	0.216
$CD8^+$ T cells	1 day before operation	24.07 ± 2.73	24.28 ± 2.89	0.608	0.544
	1 day after operation	23.79 ± 2.62	24.14 ± 2.64	1.086	0.279

CD, Cluster of Differentiation; NK cells, Natural killer cells; Treg cells, regulatory T cells.

Table 3. Comparison of self-rated aesthetic outcomes between the two groups.

Indicators	Endoscopic BCS group (n = 126)	Conventional BCS group (n = 135)	χ^2	p
I	84 (66.67%)	68 (50.37%)	7.953	0.047
II	30 (23.81%)	42 (31.11%)		
III	10 (7.94%)	21 (15.56%)		
IV	2 (1.59%)	4 (2.96%)		

Complications

The incidence of axillary pain was notably lower in the endoscopic BCS group, affecting 15.87% of patients, as compared to 32.59% in the conventional BCS group (p = 0.002) (Table 4). Similarly, numbness or paresthesia was reported in 17.46% of the endoscopic BCS group, as opposed to 34.07% in the conventional BCS group (p = 0.002). The occurrence of arm swelling was also reduced in the endoscopic BCS group, with 11.11% experiencing this complication compared to 23.7% in the conventional BCS group (p = 0.008). These results indicate that the endoscopic method may be associated with a lower risk of certain postoperative complications in elderly patients undergoing BCS.

Survival Time

The disease-free survival curves of the endoscopic BCS group and the conventional BCS group were not significantly separated (Fig. 3, p = 0.93). At the 1-year follow-up, the progression-free survival rates were comparable between the two groups. Specifically, the endoscopic BCS group had a progression-free survival of 95.19% (99/104), while the conventional BCS group showed 94.44% (102/108). By the 3-year follow-up, the progression-free survival in the endoscopic BCS group decreased to 86.75% (72/83), compared with 88.10% (74/84) in the conventional BCS group. At the 5-year follow-up, the endoscopic BCS group exhibited a further decline to 72.22% (26/36), whereas the conventional BCS group maintained a rate of 76.32% (29/38). No statistically significant differences were observed between the two groups. These findings suggest that endoscopic BCS does not compromise long-term oncological safety in elderly patients and both surgical approaches offer comparable efficacy in terms of disease-free survival in elderly patients with breast cancer.

The overall survival curves of the stratified endoscopic group and the conventional group did not show statistical differences (Fig. 4, p = 0.83). At 1-year follow-up, overall survival rates were 98.08% (102/104) in the endoscopic BCS group versus 98.15% (106/108) in the conventional BCS group. By 3-year follow-up, survival rates declined to 92.77% (77/83) and 94.04% (79/84) in the two groups, respectively. At 5-year follow-up, rates further decreased to 83.33% (30/36) in the endoscopic BCS group and 84.21% (32/38) in the conventional BCS group. This finding suggests that endoscopic BCS does not compromise long-term oncological safety in elderly patients, and both surgical approaches offer comparable efficacy in terms of disease-free survival in elderly patients with breast cancer.

Discussion

In this study, we conducted a comparative retrospective analysis of endoscopic BCS and conventional BCS in elderly patients with early-stage breast cancer. The most notable differences from the comparative analysis highlight reduced intraoperative blood loss and lower hospitalization expenses as the advantages of the endoscopic approach. The mean blood loss during endoscopic surgery was substantially lower, which can be attributed to the minimally invasive nature of the procedure. Endoscopic techniques allow for precise dissection and coagulation using electrocautery under magnified vision, thus reducing inadvertent bleeding [18]. Endoscopic surgery is also associated with fast recovery, short hospitalization time, and lower surgical costs, significantly reducing hospitalization expenses compared to conventional surgery. Cost efficiency in healthcare is an increasingly important aspect, and these findings underscore the economic benefits that endoscopic BCS may offer, especially in resource-limited settings.

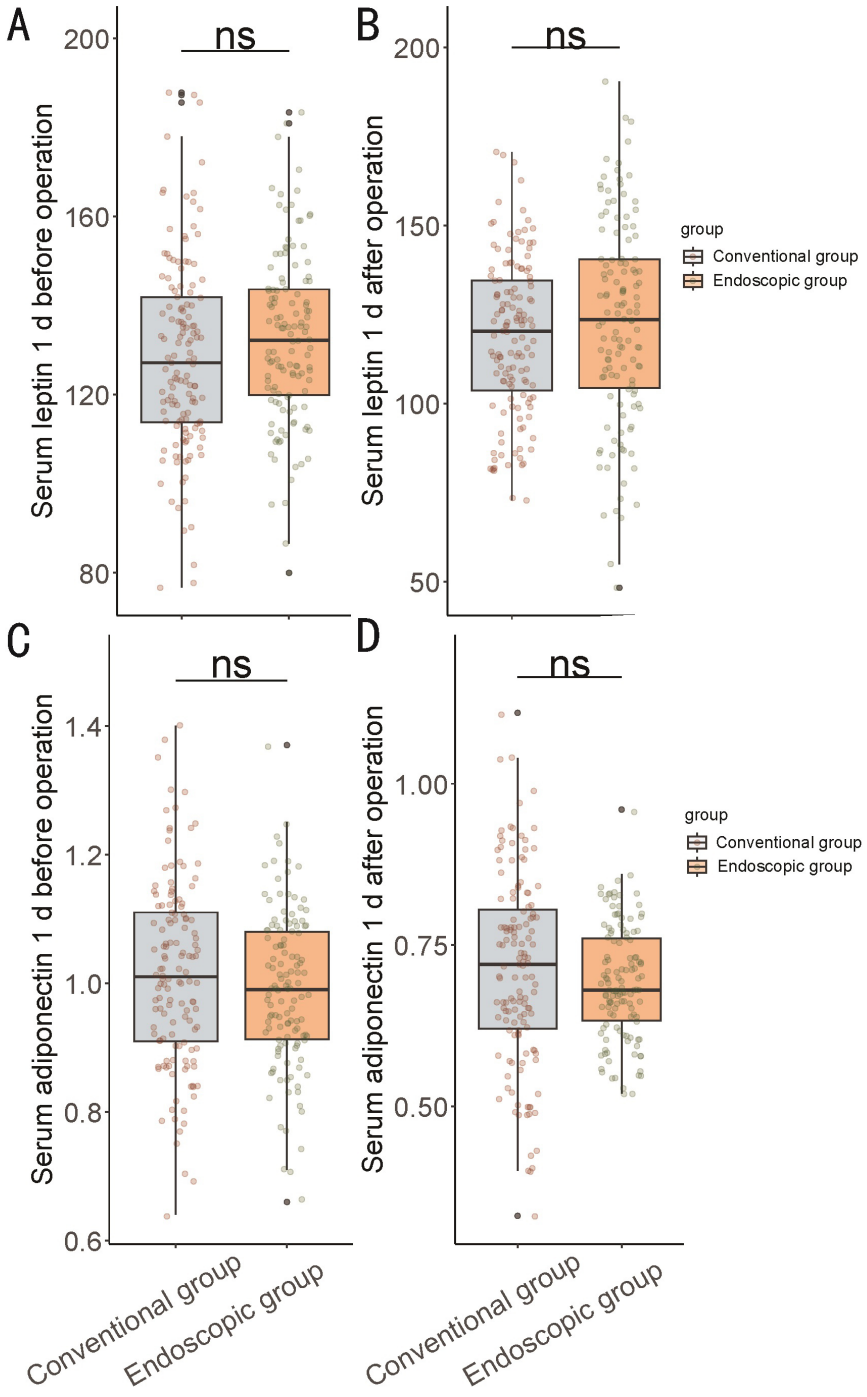

Fig. 2. Comparison of preoperative and postoperative adipokines between endoscopic and conventional breast-conserving surgery groups. (A) Serum leptin 1 day before operation; (B) Serum leptin 1 day after operation; (C) Serum adiponectin 1 day before operation; (D) Serum adiponectin 1 day after operation. ns: no statistically significant difference. The charts were created with the R software package 3.0.2. (Free Software Foundation, Inc., Boston, MA, USA).

From an aesthetic standpoint, our analysis indicated a substantial preference among patients for the aesthetic outcomes of endoscopic surgery. This can be largely explained by the technique's tissue-sparing nature. Endoscopic surgery allows for smaller incisions and less scarring, preserving breast contour and symmetry post-operatively. Aesthetic satisfaction was critical in breast cancer surgery, particularly among elderly patients, who may have a heightened focus on the quality of life post-treatment. Superior aesthetic outcomes achieved by subjects in the endoscopic BCS group may reduce their psychosocial morbidity, particularly in those with ptotic breasts. These findings suggest that the endoscopic method might be preferred by patients who prioritize aesthetic outcomes, facilitating

Table 4. Comparison of surgical complications between the two groups.

Indicators	Endoscopic BCS group (n = 126)	Conventional BCS group (n = 135)	χ^2	p
Axillary pain	20 (15.87%)	44 (32.59%)	9.843	0.002
Numbness or paresthesia	22 (17.46%)	46 (34.07%)	9.337	0.002
Arm swelling	14 (11.11%)	32 (23.7%)	7.118	0.008

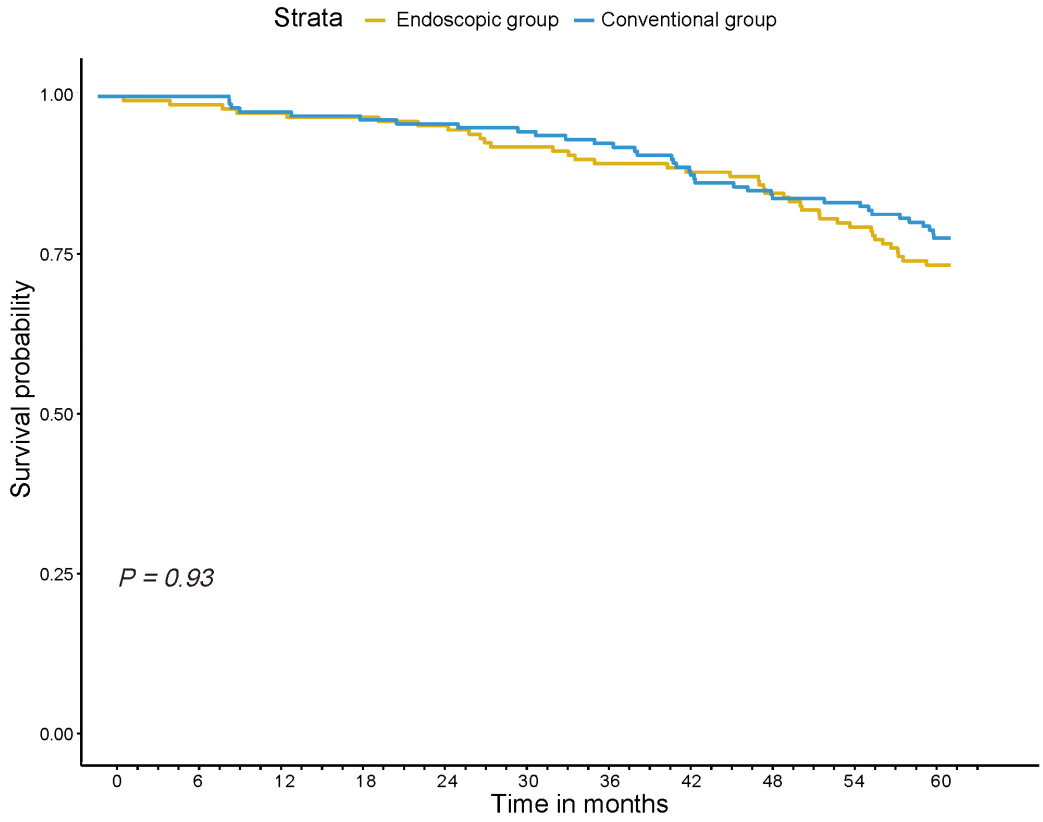

Fig. 3. Disease-free survival in the two groups. The graph was created with R software package 3.0.2. (Free Software Foundation, Inc., Boston, MA, USA).

decision-making between patient and clinician [9,19,20].

While operative times did not differ significantly between the two groups, the endoscopic group exhibited a reduced drainage duration and less drainage output. These results may be indicative of less extensive tissue manipulation and trauma during endoscopic procedures, which lead to reduced inflammatory responses. The tissue trauma reduction achieved with magnified visualization and precision cutting inherent in endoscopically assisted procedures may decrease the lymphatic disruption, which manifests as reduced postoperative edema and seroma formation. Understanding the underlying mechanisms that promote improved healing and less serous drainage can inform postoperative care practices and protocol development for breast surgeries in elderly patients [21,22].

The endoscopic approach demonstrated a marked reduction in postoperative complications, namely axillary pain, numbness or paresthesia, and arm swelling. The minimally invasive nature of the endoscopic procedure likely results in less nerve and tissue damage, contributing to these outcomes [23]. These complications often result from traditional axillary lymph node dissection, where the larger surgical incisions can increase the likelihood of nerve trauma [24–26]. Lower complication rates not only improve patient comfort but also engender quicker recovery times and reduced incidence of long-term sequela such as lymphedema, which was prevalent in this patient demographic. Elderly patients benefit particularly from reductions in such complications, given their potential comorbidities and reduced physiologic reserve.

Our study also evaluated and compared perioperative immune cell changes and adipokine levels between the study groups. The lack of significant differences suggests that both surgical methods have similar systemic immunological impacts. Minimally invasive techniques reduce tissue trauma and ischemia-reperfusion injury, which are known to trigger systemic inflammatory responses (e.g., elevated IL-6, TNF-α) and suppress adaptive immunity. Reduced surgical stress in the endoscopic BCS group might help with preserving the cytotoxic effect of NK cells and dendritic cell

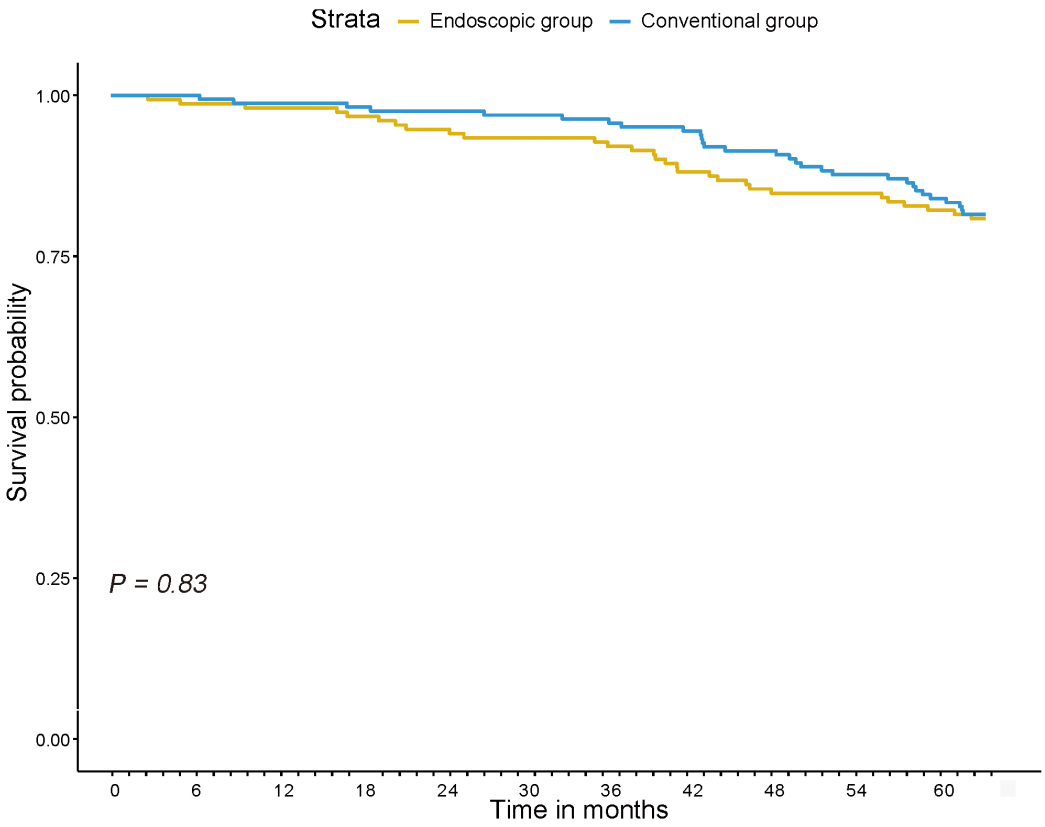

Fig. 4. Overall survival in the two groups. The graph was created with R software package 3.0.2. (Free Software Foundation, Inc., Boston, MA, USA).

antigen presentation, which are instrumental for maintaining antitumor immune surveillance. Additionally, faster postoperative recovery in the endoscopic cohort could mitigate chronic inflammation and lymphopenia, factors implicated in immunosuppression. This was a critical observation, as maintaining immune function was of paramount importance in cancer patients. Moreover, since adipokines such as leptin and adiponectin were implicated in cancer progression and metastasis [27–29], the non-alteration of these levels indicates that endoscopic surgery does not provoke additional metabolic stress compared to traditional methods.

Despite these advantages, survival outcomes in terms of both disease-free and overall survival were statistically similar between groups over the follow-up period. This parity in survival rates validates the oncological safety and effectiveness of endoscopic techniques in managing early-stage breast cancer, reassuring clinicians of its appropriateness, besides being a less invasive option. The comparable survival also mitigates concerns that reduced surgical intervention might compromise the thoroughness of cancer resection.

Our findings align with previous studies demonstrating the oncological safety of endoscopic BCS in early-stage breast cancer. For example, Gui *et al.* [30] reported that at a median follow-up of nine years, there was no significant difference in the overall recurrence rate between patients receiving endoscopic treatment and those receiving conventional treatment ($p = 0.233$). In this study, the median ages of the two groups of patients were 59 (49–65) years and 56 (48–64) years, respectively. However, our study uniquely focuses on elderly patients (age $\geq$70 years), providing a more reliable basis for the treatment of elderly breast cancer. Prior research by Tamaki *et al.* [31] suggested that endoscopic BCS has the same therapeutic oncological effect as a standard lumpectomy and offers a greater cosmetic advantage in cases of early breast cancer, but our data demonstrate benefits of endoscopic BCS to elderly individuals, such as lower rates of axillary pain (15.87% vs. 32.59%) and arm swelling (11.11% vs. 23.7%). This gives minimally invasive techniques a greater relative advantage in elderly cohorts.

There are, however, challenges to widespread adoption of endoscopic breast surgery. The necessity of advanced surgical training and increased initial investments in equipment poses institutional barriers, particularly for centers with limited resources. Furthermore, patient selection remains critical. By limiting the study to tumors favorable for endoscopic intervention, the inclusion criteria inherently exclude larger or more invasive tumors; as a result, the findings may not generalize to these patient populations. Surgeons must also consider patient preferences and clin-

ical context, balancing aesthetic and functional outcomes against potential technical difficulties of the procedure.

One of the primary limitations of this study was its retrospective design. Although we applied strict inclusion/exclusion criteria and adjusted for confounders using hospital electronic health record data, the study remains subject to inherent selection biases that may restrict its generalizability to diverse clinical settings. As the analysis was based on data from a single center, the results might not be applicable across different populations or clinical settings subjected to varying levels of surgical expertise and resources. Future multi-center randomized trials with protocolized adjuvant therapy are needed to confirm these findings. Additionally, the absence of long-term follow-up data restricts our ability to draw conclusions about the potential impact of the surgical techniques on long-term oncological outcomes and quality of life beyond the studied time frame. Although no significant differences in disease-free survival or overall survival were observed within this timeframe, extended surveillance is required to assess late recurrence risks. Furthermore, the sample size, while sufficient for observing significant differences in certain perioperative outcomes, may not have the power to detect nuanced differences in survival data, thus necessitating larger, multicentric studies to validate these findings comprehensively. Finally, variations in surgeon experience and preferences could have influenced the outcomes, underscoring the need for further standardization in surgical techniques and protocols.

Conclusions

The current study elucidates the benefits of endoscopic BCS in reducing operative morbidity and enhancing aesthetic outcomes without compromising efficacy in disease control. The remarkable improvements in postoperative recovery and reduced complication rates advocate for its consideration as a preferred surgical option among elderly candidates with unifocal tumors $\leq$3 cm. Continued studies, particularly prospective randomized controlled trials, are warranted to further delineate long-term outcomes and refine guidelines for integrating endoscopic techniques into wider oncological surgical practice. The insights gathered here potentially inform surgical decision-making, contributing to personalized cancer care and improving quality of life for breast cancer patients.

Availability of Data and Materials

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Author Contributions

WZ and JDW designed the research study. WZ, JDW, YX and YH performed the research. YH analyzed the data. WZ wrote the manuscript. All authors contributed to editorial changes in the manuscript. All authors read and approved the final manuscript. All authors have participated sufficiently in the work and agreed to be accountable for all aspects of the work.

Ethics Approval and Consent to Participate

This study was approved by the Ethics Committee of Ningbo No. 2 Hospital (No: PJ-NBEY-KY-2023-141-02). All procedures utilized in this study adhered to the ethical principles outlined in the Declaration of Helsinki. As this was a retrospective study, informed consent was waived. This waiver complied with regulatory and ethical standards for retrospective research.

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Conflict of Interest

The authors declare no conflict of interest.

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