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Single-port non-lipolytic endoscopic surgery via the axillary approach for the treatment of benign breast tumors has better clinical outcomes: a case control study

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Abstract

Background Endoscopic surgery provides good cosmetic results while ensuring therapeutic outcomes. This study aimed to evaluate the efficacy, safety, and cosmetic outcome of endoscopic surgery for benign breast tumors.

Methods In total, 108 patients were enrolled and divided into endoscopic or open surgery groups based on the patients' voluntary decisions. Surgical information, complications, postoperative pain, and postoperative cosmetic scores were compared.

Results The endoscopic surgery group and open surgery group included 46 and 62 patients, respectively. Patients who underwent endoscopic surgery had longer operative times ($p < 0.001$) and postoperative hospital stays ($p = 0.045$), and there was no significant difference in intraoperative blood loss between the two groups ($p = 0.501$). The overall postoperative complication rate was 13% in the endoscopic group and 25.8% in the open group ($p = 0.103$). Postoperative pain scores were similar in both groups. Cosmetic scores were better in the endoscopic group ($p = 0.002$), especially regarding nipple shape and wound scarring.

Conclusions Endoscopic surgery is safe and effective for treating benign breast tumors and offers improved cosmetic results compared to open surgery.

Keywords Benign breast tumor, Endoscopy, Single-port, Non-lipolytic

Background

Benign breast tumors, such as breast fibroadenomas and benign phyllodes tumors, are frequently found in young women [1]. Common surgical approaches for benign breast tumors include traditional open surgery and vacuum-assisted rotational excision [2]. Traditional open surgery can completely remove the tumor and peritumor tissue. However, the incision scar, as well as the deformation and displacement of the nipple and areola caused by the surgery, will affect the postoperative cosmetic effect. Vacuum-assisted rotary excision involves a smaller surgical incision and has the advantage of being minimally invasive, but it can only

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excise breast masses < 3 cm in diameter and cannot completely remove the tumor and capsule simultaneously [3]. Therefore, both surgical methods have certain limitations.

With the development of endoscopic surgery, it has been gradually applied to breast surgery. In 1992, Kompatscher pioneered the use of an endoscope in breast surgery by removing contractured prostheses after mammoplasty [4]. Kitamura first reported the application of endoscopic surgery for the resection of benign breast tumors in 1998, which was performed using a three-hole approach in the mid-axillary line, with blunt separation of the expanding balloon combined with CO2 insufflation to create a subcutaneous operating space [5]. The use of endoscopes in breast surgery provides clinicians with new ideas.

Endoscopic surgery for benign breast tumors using our single-port via the axillary approach builds on the experience with the previous three-port approach [6], which reduced the number of surgical incisions from three to one and may provide better postoperative cosmetic results without compromising therapeutic outcomes. The objective of this study was to evaluate the efficacy, safety, and cosmetic outcome of endoscopic surgery for benign breast tumors by comparing single-port non-lipolytic endoscopic surgery via the axillary approach with conventional open surgery.

Methods

Patient population

This study included female patients who visited the Breast Disease Center of the Affiliated Hospital of Qingdao University from October 2022 to October 2023. The eligibility criteria were age ≥ 18 years, female, solitary mass in unilateral breast (or multiple tumors but surgical resection of only one tumor), ≥ 2 cm in diameter, BI-RADS grade 3 on ultrasound and mammogram evaluation, or BI-RADS grade 4a on ultrasound or mammogram evaluation and histopathologically confirmed diagnosis of a benign tumor. The exclusion criteria were patients with a history of breast surgery, patients who were pregnant or lactating, and patients who refused to undergo postoperative follow-up. Patients were divided into the endoscopic surgery group and the open surgery group based on their voluntary decision on the type of surgery to be performed. All patients were required to undergo preoperative evaluation to rule out contraindications to surgery, including routine blood tests, biochemical panels, blood coagulation tests, blood typing, electrocardiography, chest X-ray/chest CT, breast ultrasound and mammogram.

Surgical details

Patients were marked for the location and extent of the mass preoperatively under ultrasound guidance. Prior to surgery, patients in the endoscope surgery group stood with their arms naturally hanging down, marking the position of the anterior axillary line and initially planning the location of the surgical incision. Both groups underwent surgery under general anaesthesia. Patients were in the supine position with bilateral upper extremity abduction at 90°.

For patients in the open surgery group, the surgeon selected an appropriate surgical incision based on the location and size of the tumor, usually along the skin line or along the areola. The surgeon completely removed the tumor (and capsule) and decided whether to place a drainage tube, depending on the procedure. If necessary, to fill the traumatic cavity and prevent local depression, the glands surrounding the tumor may be appropriately freed and sutured. The surgical incision was then closed with cosmetic sutures.

In the endoscopic surgery group, the surgical incision was made in the axilla on the same side of the tumor. The surgical incision was along the skin line, usually approximately 3 cm in length, and the leading edge did not extend beyond the anterior axillary line. After determining the location of the surgical incision, a straight line was drawn from each end of the surgical incision toward the edge of the tumor, and the area in the middle of the two straight lines was the body projection of the working area of the endoscopic instruments. The tissue was incised with an electrocautery knife to the lateral border of the pectoralis major muscle for access to the retromammary space. The surgeon prepared a diluted epinephrine solution and injected it evenly into the retromammary space through the incision using a porous water injection needle in the area between the two straight lines described above, which can reduce bleeding during surgery. A tunneler was used to create a surgical cavity in the retromammary space to the underside of the tumor, which facilitated the direction of surgery and more precise positioning of the surgical area. A disposable incision protector was placed over the incision, and an endoscopic single-hole sleeve was placed. The retromammary space was filled with carbon dioxide at a 6–10 mmHg pressure to create an endoscopic surgical space. Under endoscopic guidance, the tumor was progressively dissected from the bottom to the top using an electric hook, electric scissors, or an ultrasonic knife until the tumor (and the capsule) was removed entirely. If it was difficult to define the tumor margins at the time of surgery, a small amount of methylene blue may be injected transdermally around the tumor to aid in localization (Fig. 1). After removing the tumor, the surrounding glands usually did not need

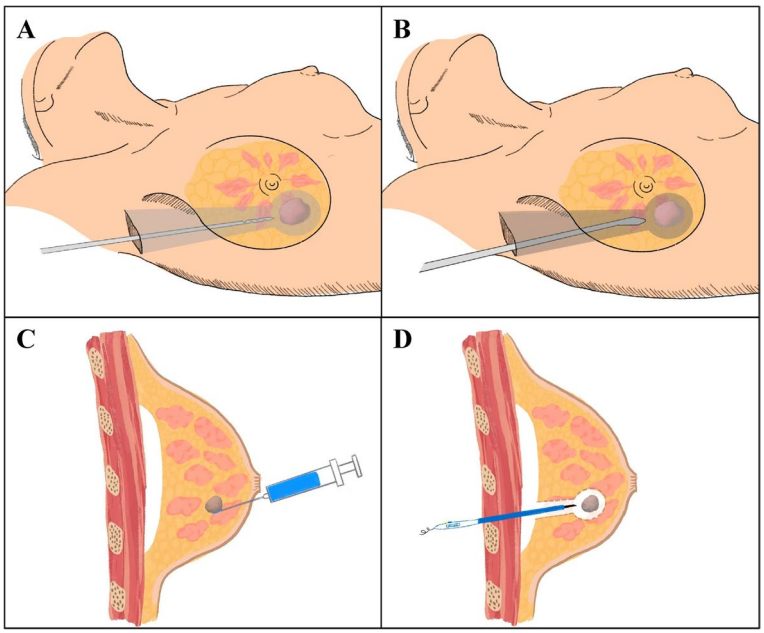

Fig. 1 Schematic diagram of the endoscopic procedure. **A** The gray shaded area is the body projection of the working area of the endoscopic instruments. A porous water injection needle is used to inject diluted adrenaline solution evenly into the above-mentioned area of the retromammary space. **B** A tunneler is used to create a surgical cavity in the retromammary space to the underside of the tumor. **C** A small amount of methylene blue can be injected transdermally around the tumor to aid in localization. **D** The tumor is progressively dissected from the bottom to the top until the tumor (and the capsule) is removed entirely

suturing. Based on the intraoperative situation, the surgeon decided whether to place a drainage tube. The surgical incision was closed with cosmetic sutures.

Evaluation of surgical complications

The common complications of surgery for benign breast tumors, including hemorrhage and/or hematoma, infection, seroma, poor incisional healing, and nipple-areola ischemia, were statistically analysed in this study. Subcutaneous emphysema, a possible complication of endoscopic surgery, was also included. All complications were graded according to the Clavien-Dindo classification system [7].

Evaluation of postoperative pain

All patients routinely received a pain rating at 24 h postoperatively. The 0–10 version of the Numerical Rating Scale (NRS) was used, with patients choosing from a total of 11 ratings in 4 categories: 0 for no pain, 1 to 3 for mild pain, 4 to 6 for moderate pain, and 7 to 10 for severe pain [8].

Evaluation of cosmetic outcomes

Patients were evaluated for satisfaction with the cosmetic outcome of the surgery in an outpatient clinic three months postoperatively. Cosmetic outcomes were assessed using a 5-point scoring system (ABNSW) [9]. The five items are asymmetry (A), breast shape (B), nipple shape (N), skin condition (S), and wound scar (W). Each item is rated on a scale of 0–3: 0 means poor, 1 means fair, 2 means good, and 3 means excellent. The scores for the five items are then summed, with a maximum total score of 15. Scores are defined as follows: 5 or less indicates poor, 6–10 indicates fair, 11–14 indicates good, 15 indicates excellent.

Statistical analysis

The Kolmogorov–Smirnov test was used to test the Gaussian distribution of the data, where $p > 0.05$ indicated that the conformation was normally distributed. Normally distributed data were reported as $(\bar{x} \pm s)$ in this paper and analysed by independent samples t-test. Data that did not conform to a normal distribution were expressed as the median (interquartile range) and were analysed by the Mann–Whitney U test. Enumeration data were expressed as numbers (%) and analysed by chi-squared test or Fisher's test. The level of significance was $\alpha = 0.05$, and $p < 0.05$ was considered to indicate statistical significance. All the statistical analyses were performed with SPSS software (version 26.0. SPSS Inc., Chicago, IL).

Results

General information

A total of 108 eligible patients were enrolled from October 2022 to October 2023. There were 46 patients in the endoscopic surgery group and 62 in the open surgery group. The mean age of the enrolled patients was 27.4 ± 5.7 years (range, 18 ~ 43 years), and the median maximum tumor diameter assessed by preoperative ultrasound was 3.5 cm (range, 2.0 ~ 7.5 cm). The general information of the two groups is shown in Table 1. In terms of age, BMI (Body Mass Index), tumor site, tumor location, distance from the center of the nipple to the proximal part of the tumor, and length of the maximum tumor diameter as assessed by preoperative ultrasound, there were no significant differences between the two groups.

Surgical and pathologic information

There were no intraoperative complications in either group, and all patients in the endoscopic surgery group completed the surgery without conversion to open surgery midway. The median duration of surgery in the open surgery group was 50 min (range, 40 ~ 70 min), significantly shorter than the 90 min (range, 50 ~ 150 min) in the endoscopic surgery group ($p < 0.001$). Intravenous anaesthesia was generally used in the open surgery group, and tracheal intubation was used in the endoscopic surgery group. There was no significant difference in intraoperative blood loss or the percentage of tracheal drains between the two groups. In the endoscopic surgery group, 23.9% of patients were hospitalized two days after surgery compared to 9.7% in the open surgery group ($p = 0.045$) (Table 2).

Pathology revealed that breast fibroadenoma accounted for the greatest percentage (77.8%, 84/108), followed by benign phyllodes tumors (12.0%, 13/108), and a small number of lipomas, hamartomas, etc. The maximum diameter length of the tumor determined by pathology was significantly greater in the endoscopic surgery group than in the open surgery group (3.8 cm vs. 3.2 cm, $p = 0.014$) (Table 2).

Postoperative complications

The overall postoperative complication rate of the enrolled patients was 20.4% (22/108). This percentage was 13.0% (6/46) in the endoscopic surgery group, which was lower than the 25.8% (16/62) in the open surgery group ($p = 0.103$). Although the overall postoperative complication rate was not significantly different between the two groups, the results suggest a trend toward a reduction in postoperative complications with endoscopic surgery. The most common postoperative complication was seroma, with an incidence of 7.4% (8/108). Other postoperative complications included poor incisional healing (4.6%, 5/108), hemorrhage and/or hematoma (2.8%, 3/108), infection (2.8%, 3/108), and nipple-areola ischemia (2.8%, 3/108). Both groups had similar incidences of all types of postoperative complications. The endoscopic surgical incision was made in the axilla, which avoided the use of an open circumareolar surgical incision for tumors in the central breast region and reduced the risk of postoperative nipple areola ischemia (0 vs. 4.8%). Subcutaneous emphysema, a common complication of endoscopic surgery reported in other studies, was not observed in this study (Table 3).

Table 1 Comparison of general information between the endoscopic surgery group and the open surgery group

Characteristics		Endoscopic surgery group (n = 46)	Open surgery group (n = 62)	u/t/χ2	p Value
Age (years old)		26.8 ± 6.3	27.9 ± 5.2	−0.982	0.329
BMI (kg/m^2)		22.6 (4.0)	22.3 (3.2)	1266.000	0.320
Tumor site	Left	25 (54.3%)	36 (58.1%)	0.148	0.700
	Right	21 (45.7%)	26 (41.9%)		
Tumor location	Upper outer quadrant	15 (32.6%)	13 (21.0%)	6.041	0.196
	Lower outer quadrant	5 (10.9%)	15 (24.2%)		
	Lower inner quadrant	7 (15.2%)	12 (19.4%)		
	Upper inner quadrant	5 (10.9%)	10 (16.1%)		
	Nipple areola area	14 (30.4%)	12 (19.4%)		
Distance from the center of the nipple to the proximal part of the tumor (cm)		2.0 (3.5)	2.0 (2.0)	1421.000	0.975
Maximum tumor diameter assessed by preoperative ultrasound (cm)		3.6 (1.7)	3.4 (1.2)	1124.500	0.061

Table 2 Comparison of surgical and pathologic information between the endoscopic surgery group and the open surgery group

Characteristics		Endoscopic surgery group (n = 46)	Open surgery group (n = 62)	u/χ2	p Value
Duration of surgery (min)		90.0 (40.0)	50.0 (10.0)	169.000	< 0.001
Intraoperative blood loss (mL)		5.0 (0)	5.0 (0)	1349.000	0.501
Placing drainage tubes	Yes	30 (65.2%)	37 (59.7%)	0.344	0.557
	No	16 (34.8%)	25 (40.3%)		
Postoperative hospitalization days	One day	35 (76.1%)	56 (90.3%)	4.035	0.045
	Two days	11 (23.9%)	6 (9.7%)		
Pathological diagnosis of tumor	Fibroadenoma	34 (73.9%)	50 (80.6%)	0.864	0.649
	Benign phyllodes tumor	7 (15.2%)	6 (9.7%)		
	Others	5 (10.9%)	6 (9.7%)		
Maximum tumor diameter assessed by pathological examination (cm)		3.8 (1.9)	3.2 (0.9)	1031.000	0.014

Table 3 Comparison of postoperative complications between the endoscopic surgery group and the open surgery group

Complications	Endoscopic surgery group (n = 46)	Open surgery group (n = 62)	χ2	p Value
Hemorrhage and/or hematoma	1 (2.2%)	2 (3.2%)		
Infection	1 (2.2%)	2 (3.2%)		
Seroma	3 (6.5%)	5 (8.1%)		
Poor incisional healing	1 (2.2%)	4 (6.5%)		
Nipple-areola ischemia	0 (0)	3 (4.8%)		
Subcutaneous emphysema	0 (0)	0 (0)		
Overall Complications	6 (13.0%)	16 (25.8%)	2.652	0.103

Postoperative complications were evaluated according to the Clavien-Dindo grading system, and all postoperative complications that occurred in the enrolled patients were graded as Clavien-Dindo I-II. No severe complications occurred. Complications were treated with dressing changes, drainage, compression bandages, etc. Patients who developed postoperative infections were treated concomitantly with oral antibiotics.

Postoperative pain scores and cosmetic outcomes

The pain status of the patients was assessed at 24 h postoperatively. Most patients (77.8%, 84/108) experienced mild pain at 24 h postoperatively and did not require analgesics; others (22.2%, 24/108) experienced moderate pain that could be relieved with ibuprofen or celecoxib. There was no significant difference in postoperative pain scores between the two groups ($p = 0.344$) (Table 4).

Cosmetic results were evaluated three months postoperatively. There were no significant differences in the scores for breast symmetry ($p = 0.367$), breast shape ($p = 0.234$), or skin condition ($p = 0.488$) between the two groups. The endoscopic surgery group had significantly better nipple shape ($p = 0.036$) and wound scar ($p = 0.007$) scores than the open surgery group. Overall, the ABNSW of patients in the endoscopic surgery group was significantly better than that of patients in the open surgery

Table 4 Comparison of postoperative pain scores and cosmetic outcomes between the endoscopic surgery group and the open surgery group

Evaluation indicators		Endoscopic surgery group (n = 46)	Open surgery group (n = 62)	u	p Value
NRS		3 (2)	2.5 (1)	1279.500	0.344
ABNSW	Asymmetry	3 (1)	2 (1)	1296.000	0.367
	Breast shape	3 (1)	2 (1)	1255.000	0.234
	Nipple shape	2 (1)	2 (1)	1119.500	0.036
	Skin condition	2 (1)	2 (1)	1326.000	0.488
	Wound scar	2 (1)	2 (1)	1031.000	0.007
	Total	12 (2)	11 (2)	927.500	0.002

group, suggesting that patients who underwent endoscopic surgery achieved better postoperative cosmetic results (median score 12 vs. 11, $p=0.002$) (Table 4).

Discussion

In the evolution of breast surgery, narrowing incisions, reducing surgical trauma, preserving function, and focusing on cosmetic results have become major trends in recent years. Endoscopic surgery has the following main advantages: minimally invasive and hidden incisions, resulting in better postoperative cosmetic results; more delicate surgical operation, facilitating precise hemostasis and accurate removal of lesions; faster postoperative recovery for the patient and less physical and psychological trauma [10–12]. Endoscopic surgery is gradually changing the traditional treatment concepts and methods of breast surgeons due to its unique therapeutic and cosmetic advantages. An increasing number of surgeons have begun to perform endoscopic breast surgery, which includes endoscopic surgery for benign breast tumors, endoscopic breast-conserving surgery, endoscopic-assisted surgery for subcutaneous glandular excision and reconstruction of the breast, treatment of gynecomastia, and shape adjustment after breast reconstruction surgery [13–15].

The primary technical concept is to transfer the incision on the surface of the breast to the armpit or near the areola with the help of an endoscope and to create a surgical space using pulling hooks, suspension, lipolysis, or gas filling [16, 17]. The lack of a natural body cavity in the breast makes it critical to choose the appropriate method to create space for the endoscope. The most commonly used method for building the breast cavity is lipolysis. However, lipolysis and liposuction may cause damage to the normal structure of the breast and may not be conducive to complete removal of the tumor. Therefore, we used the inflation method to create a surgical space to utilize a potential gap, the retromammary space, between the mammary gland and the pectoralis major fascia. We used a single-port approach in the axilla to minimize the impact of surgical incision scarring on postoperative cosmetic results. At the same time, the direction of tumor removal from the retromammary space to the body surface can better reduce the breast surface depression caused by tumor removal.

In this study, there was no significant difference in intraoperative blood loss between patients in the endoscopic surgery group and those in the open surgery group, which is the same result as in a previous study [18]. The duration of surgery was significantly longer in the endoscopic surgery group than in the open surgery group, which may be related to the limited peripheral field of view under the endoscope and the chopstick effect of single-port surgery [19]. In addition, the surgeon's skill also affects the operative time. The patients included in this study were from the same surgical team, which eliminates the effect of different surgeons on the duration of surgery. Along the time axis, recent patients in the endoscopic group had shorter operative times than earlier patients. Results from related studies have also shown a trend toward shorter endoscopic procedure times with increasing experience [20, 21]. Lu et al. reported that when there were three or more tumors, patients in the endoscopic surgery group had significantly shorter operation times than did those in the open surgery group, suggesting that endoscopic surgery was more amenable to removing multiple tumors than open surgery [18]. More than 90% of the patients in the open group were hospitalized for one day postoperatively, whereas 23.9% of the patients in the endoscopic surgery group were hospitalized for two days postoperatively to meet discharge requirements. This may be due to the longer duration of the endoscopic procedure and the use of tracheal intubation anaesthesia, which requires longer hospitalization for observation.

Regarding postoperative complications, the overall complication rate in the endoscopic surgery group was 13%, which was lower than the 25.8% in the open surgery group. The rates of various complications were also numerically lower in the endoscopic surgery group than in the open surgery group, which is also in general agreement with the findings of Lu et al. [18]. In particular, endoscopic surgery reduces or even avoids the risk of postoperative nipple-areola ischemia, which is essential for patients with large tumors located in the central region of the breast. No subcutaneous emphysema was reported in this study. Excessive pressure may cause subcutaneous emphysema outside the surgical field when CO2 inflation is used to create the surgical space [22]. We effectively prevented the occurrence of subcutaneous emphysema by maintaining the code of practice safety threshold of less than 10 mmHg inflation pressure at all times during the procedure [17]. In addition to the short-term complications observed in this study, endoscopic surgery may also reduce the risk of some long-term postoperative complications. Bijkerk et al. suggested that surgical incision of the circumareolar region may result in decreased sensation in the nipple-areola region, whereas endoscopic surgery prevents this sensory abnormality caused by nerve damage [23]. At the same time, the axillary surgical incision minimizes damage to the large mammary ducts and reduces the potential risk of subsequent lactational mastitis.

In this study, there was no significant difference in pain scores between the two groups at 24 h postoperatively, and most of the patients experienced only mild pain,

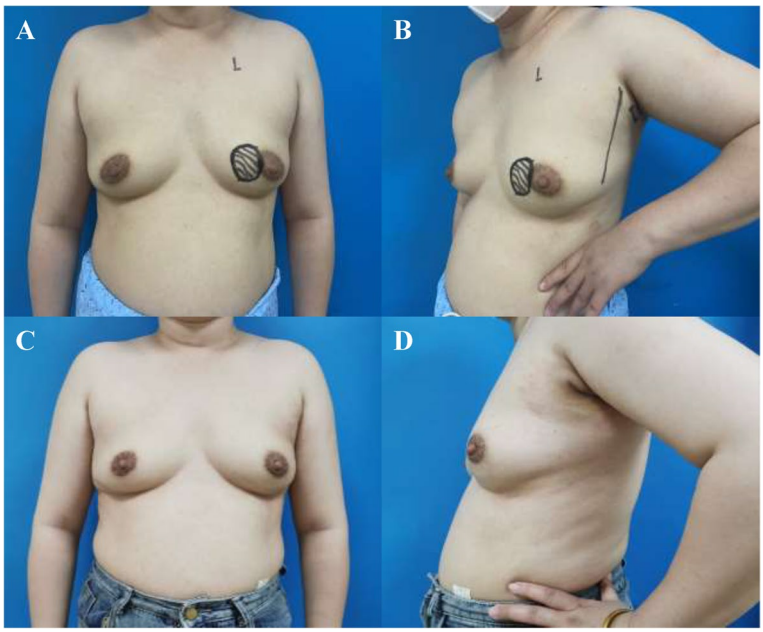

Fig. 2 Comparison of preoperative and postoperative outcomes for a patient. **A**-**B**. Preoperative photos. Tumor location and extent were marked preoperatively under ultrasound guidance. The anterior axillary line was drawn, and the incision for the endoscopic surgery was planned. **C**-**D**. Follow-up photo of the patient at three months after surgery. The surgical incision was hidden, with good cosmetic results

indicating that the patients tolerated the procedure well. Patients in the endoscopic surgery group had significantly greater cosmetic scores (ABNSWs) than those in the open surgery group, especially regarding nipple shape and wound scarring. In open surgery, scarring from circumareolar incisions or incisions close to the nipple-areola after healing, fat necrosis caused by cauterization of subcutaneous fat with an electrosurgical knife, and tissue loss caused by excision of a large tumor in the central area of the breast may result in deformation, deviation, or displacement of the nipple after surgery, resulting in decreased aesthetics. The hidden surgical incision of the endoscopic surgery group was within the anterior axillary line, which was concealed by the natural sagging of the upper limb, allowing for a better cosmetic result for the breast (Fig. 2). In addition, using a resection direction from the retromammary space toward the tumor, endoscopic surgery allows maximum subcutaneous fat and superficial glandular tissue protection, reducing the likelihood of localized postoperative indentation.

This study is subject to several limitations. Firstly, the retrospective design of this study, which was unable to intervene in patients' surgical choices, was inevitably influenced by confounding factors. Secondly, the sample size of this study was relatively limited, and the statistical analysis of some of the complications was not as comprehensive as it could have been. A prospective study with an expanded sample size will be conducted for further investigation. Ultimately, the absence of long-term follow-up data hinders the evaluation of long-term complications or tumor recurrence. However, this study provides some ideas for the technical development of endoscopic breast surgery by presenting our innovatively improved endoscopic surgery for removing benign breast tumors and providing directions for further research.

Conclusions

For benign breast tumors, single-port non-lipolytic endoscopic surgery through the axillary approach is a safe and effective surgical procedure that can provide cosmetic results superior to those of open surgery. Thus, it can be used as one of the surgical options for patients.

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Authors' contributions
T.M. wrote the main manuscript text. J.C. and Q.W. completed the data collection. C.L. conducted data analysis. B.W. provided the writing ideas for the manuscript. H.W. supervised this study, reviewed and revised the manuscript.

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Data availability
The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
The study protocol complied with governmental guidelines and the Declaration of Helsinki, and was approved by the Institutional Review Committee of the Affiliated Hospital of Qingdao University (QYFY-WZLL-37103). Patients enrolled in the study were informed and provided with informed consent for the utilization of their case data and subsequent follow-up information.

Consent for publication
Patients have signed a consent form before taking photos, and they have agreed to use their photos for article publication and scholarly communication.

Competing interests
The authors declare no competing interests.

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