Single-Port Insufflation Endoscopic Nipple-Sparing Mastectomy in Early Breast Cancer: A Retrospective Cohort Study

Zi-Han Wang

Capital Medical University Affiliated Beijing Friendship Hospital

Wei-Hua Liu

Capital Medical University Beijing Obstetrics and Gynecology Hospital

Shan-Shan Wu

Capital Medical University Affiliated Beijing Friendship Hospital

Yi-Ming Tian

Capital Medical University Beijing Obstetrics and Gynecology Hospital

Jun Liu

Capital Medical University Affiliated Beijing Friendship Hospital

Guo-Xuan Gao

Capital Medical University Affiliated Beijing Friendship Hospital

Fang Xie

Beijing Hospital of Traditional Chinese Medicine

Guo-Qian Ding

Capital Medical University Affiliated Beijing Friendship Hospital

Xiang Qu (✉ [cxq3968@ccmu.edu.cn](mailto:cqx3968@ccmu.edu.cn))

Capital Medical University Affiliated Beijing Friendship Hospital <https://orcid.org/0000-0002-7969-1056>

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Abstract

Purpose

To compare the oncologic safety, aesthetic outcome, and upper extremity function of single-port insufflation endoscopic nipple-sparing mastectomy (SIE-NSM) vs conventional open mastectomy (C-OM) in the treatment of early breast cancer.

Methods

In this retrospective cohort study, 285 stage I and II breast cancer patients were divided into the SIE-NSM group ($n = 71$) and the C-OM group ($n = 214$). Local recurrence, distant metastasis, and upper extremity function were compared. Differences in the aesthetic outcome, psychosocial well-being, and sexual well-being were analyzed by the BREAST-Q scale. Multivariable binary logistic regression was conducted to assess the risk of local recurrence. The multivariable linear regression model was performed to evaluate the upper extremity function and the aesthetic outcome.

Results

Local recurrence rates were similar ($p = 0.735$), which was also shown by multivariable binary logistic regression analysis. No distant metastases were observed in either group. Satisfaction with breasts, chest well-being, psychosocial well-being, and sexual well-being scores were superior in the SIE-NSM group ($p < 0.001$). Chest wall/breast pain, shoulder range of motion, and use of arm in daily life was better for the patients in the SIE-NSM group ($p < 0.001$). There were no cases of subcutaneous effusion in the SIE-NSM group, while the incidence rate of subcutaneous effusion in the C-OM group was 10.7% ($p = 0.004$).

Conclusions

SIE-NSM is comparable to C-OM in oncologic safety while increasing satisfaction with breasts, physical well-being, psychosocial well-being, sexual well-being, and upper extremity function. This novel method is an appropriate surgical option for early breast cancer treatment.

Introduction

Breast cancer is the most prevalent malignant tumor type threatening female health globally, and its annual morbidity rates have been increasing at a remarkable pace in recent years [1, 2]. Because the breast is an important sexual organ, breast cancer patients have a higher demand for post-surgical/post-treatment breast appearance, aesthetic outcome, and psychosocial and sexual well-being.

Conventional open mastectomy (C-OM) results in a major change in breast appearance with massive loss of skin and limited traction and movement of the affected upper extremity. These factors seriously influence a patient's quality of life [3]. The development of the nipple-sparing mastectomy (NSM), in which the nipple-areola complex (NAC) is preserved, slightly improved the postoperative aesthetic

outcome [4, 5], and the quality of life and satisfaction of the patients improved too[6–8]. However, a conspicuous surgical scar remains on the chest wall after open NSM. An areolar incision can be used to reduce the size of the scar, but it is accompanied by a high NAC necrosis rate [9]. Therefore, open NSM cannot fully meet the aesthetic demand of patients.

Endoscopic surgery is widely utilized in clinical practice due to the advantages of a small, unobtrusive incision and rapid recovery. Development of the endoscopic technique in breast cancer surgery is urgently needed to beneficially impact the aesthetic outcome, psychosocial well-being, and upper extremity function. At our center, we use the single-port insufflation endoscopic nipple-sparing mastectomy (SIE-NSM) technique to make a small and covert single-port incision in the axillary fossa instead of chest wall. This avoids the impact of an areolar incision on the NAC blood supply. In this study, we compared SIE-NSM to C-OM and analyzed the differences in oncologic safety, aesthetic outcome, psychosocial well-being, sexual well-being, and upper extremity function.

Materials And Methods

Ethics Statement

This study was approved by the Ethics Committee of the Beijing Friendship Hospital, Capital Medical University (document number: 2019-P2-033-02). Written informed consents were obtained from all patients before surgery.

Data Source and Patient Selection

This was a retrospective cohort study. A total of 285 patients with stage I and II breast cancer were consecutively enrolled. They underwent surgery at the Beijing Friendship Hospital from January 2014 to October 2018. In total, 71 patients received SIE-NSM, and 214 patients received C-OM (Table 1).

Table 1
Patient characteristics (*N* = 285)

	SIE-NSM group	C-OM group	<i>p</i> -value
	(<i>n</i> = 71)	(<i>n</i> = 214)	
Age (years)	52.6 ± 10.6	56.7 ± 8.7	0.001
BMI (kg/m ²)	22.9 ± 3.0	23.3 ± 2.7	0.381
Tumor size (cm)	1.7 ± 0.6	2.0 ± 0.6	0.002
Follow-up time (months)	40.1 ± 21.3	39.1 ± 16.7	0.715
TNM stage			0.661
I	50 (71.0%)	143 (66.8%)	
II	21 (29.0%)	71 (33.2%)	
ER			0.873
+	55 (77.5%)	162 (75.7%)	
-	16 (22.5%)	52 (24.3%)	
PgR			0.775
+	47 (66.2%)	136 (63.6%)	
-	24 (33.8%)	78 (36.4%)	
HER2 ¹			0.773
+	25 (35.2%)	71 (33.2%)	
-	46 (64.8%)	143 (66.8%)	
¹ HER2 status was estimated by immunohistochemistry or in situ hybridization. Tumors were HER2 positive if the average HER2 gene/chromosome 17 ratio was 2, or the average HER2 gene copy number was 6. SIE-NSM: Single-port insufflation endoscopic nipple-sparing mastectomy; C-OM: Conventional open mastectomy; BMI: Body mass index; TNM: Tumor node metastasis; ER: Estrogen receptor; PgR: Progesterone receptor; HER2: Human epidermal growth factor receptor, type 2.			

The inclusion criteria for patients were as follows: (1) diagnosis of stage I or II invasive ductal carcinoma; (2) no involvement of the nipple and skin as determined by physical examination and magnetic resonance imaging, and the tumor was confined to the mammary gland as confirmed by magnetic resonance imaging; (3) the diameter of the tumor was no more than 3 cm, the distance between the lesion and nipple was > 3 cm, and clinically negative infused axillary nodes were present; (4) breast-conserving therapy cannot be performed because of the presence of diffused suspicious neoplastic foci

or microcalcifications and the small size of the breast; (5) unwilling to undergo breast reconstruction surgery for personal reasons; (6) age between 18 and 70 years old; and (7) Eastern Cooperative Oncology Group scoring from 0–2.

The exclusion criteria were as follows: (1) suffering from severe internal disease including cardiovascular disease, myocardial infarction, and cerebrovascular disease; (2) pregnant or lactating; (3) other tumor history within the past five years; (4) continued systemic steroid therapy or organ transplantation requiring immunosuppressive therapy; and (5) severe breast ptosis.

To avoid the impact of breast reconstruction on the local recurrence and BREAST-Q scores, the patients requiring breast reconstruction combined with SIE-NSM were not enrolled in this study.

Clinicopathologic Parameters

The primary end point was local recurrence within two years after operation. The secondary end points were distant metastasis, satisfaction with breasts, chest well-being, psychosocial well-being, sexual well-being, incidence of subcutaneous effusion, and upper extremity function (including upper arm pain, chest wall/breast pain, range of shoulder, and use of arm in daily life).

Surgical Procedures

SIE-NSM

The optic and endoscopic instruments were all provided in the laparoscopy equipment kit and were reusable (Olympus Optical Co., Tokyo, Japan). The patient was placed in the supine position with the ipsilateral arm abducted 90° with the ipsilateral body elevated.

To classify the blood supply mode of the NAC, we injected 4 mL of 2.5 mg/mL of indocyanine green solution (ICG) by intravenous drip and applied the ICG angiography immediately. Carbon nanoparticle suspension was injected around the areola to trace the sentinel lymph nodes. Fifteen minutes later, we made a 2.5 cm single-port incision along the wrinkles of the axilla. We performed the sentinel lymph node biopsy through this incision under direct vision. The intraoperative frozen pathology determined whether to perform axillary lymph node dissection.

To create an operating space for the endoscopic procedures and reveal the breast membrane anatomy, tumescent solution infiltration and liposuction were performed before the mammary gland resection. The formula of tumescent solution was: 1 mg of adrenaline and 20 mL of 2% lidocaine in a mixture of 250 mL of 0.9% sodium chloride and 250 mL of sterilized distilled water. The tumescent solution was injected into the subcutaneous layer and retromammary space through the single-port incision. Ten minutes later, a liposuction tube with a vacuum of 800 mbar was inserted in both the subcutaneous layer and retromammary space. The adipose tissue around the mammary gland was removed.

We created an adequate working space by the insufflation method. We placed the single-port insufflation kit (HTKD-Hang T Port, China) into the same single-port incision. This single-port insufflation kit had two

pathways on both sides. Carbon dioxide (8 L per minute) was used to maintain the pressure at 8 mmHg. On the surface of the single-port insufflation kit, there were four plastic trocars for inserting different endoscopic surgical instruments into the operating cavity (Fig. 1).

We performed SIE-NSM through this single-port insufflation kit. First, the retromammary space was separated. The retromammary space was visible after liposuction and carbon dioxide input (Fig. 2). The mammary gland and the pectoralis major were easily separated by dissecting the fibrous connective tissue. The mammary gland was separated from the skin flap by severing the Cooper's ligaments, which were the only remaining attachment following liposuction (Fig. 3). The gland was only connected by the peripheral ligaments, including the clavicular ligaments, medial sternal ligaments, lateral pectoralis major ligaments, and horizontal ligaments (Fig. 4) [10]. By breaking these ligaments with electrocautery, the gland was completely dissociated. Finally, the entire breast specimen was removed through the base of the single-port insufflation kit, which could prevent incision implantation metastasis (Fig. 5). The stump of the nipple site and the dissected surfaces of the tumor were intraoperatively submitted for frozen section cytology.

C-OM

The operative position and the sentinel lymph node tracing were the same for C-OM as described above for SIE-NSM. We made a spindle-shaped incision on the surface of the breast including the NAC that was approximately 15 cm long. Then, the entire breast tissue was removed and sent to pathology. Sentinel lymph node biopsy was performed. Axillary lymph node dissection was performed if the frozen section examination showed positive results.

Postoperative management

In the C-OM group, two closed suction drainage tubes were placed. In SIE-NSM group, one drainage tube was placed through the single-port incision because subcutaneous effusion is very rare. When the drainage volume was less than 30 mL for three consecutive days, then the drainage tube was removed. The pressure bandaging was used for two weeks after removing the drainage tube. According to the National Comprehensive Cancer Network guidelines, all of the patients were able to accept corresponding chemotherapy, endocrine therapy, and targeted therapy [11].

Follow-up

All patients were followed up by telephone and questionnaire. The aesthetic outcome was evaluated using the BREAST-Q scale [12]. The upper extremity function was evaluated by questionnaire with scores ranging from 1–10 (1 indicated the worst function, and 10 indicated the best function).

Statistical Analysis

Sample size was determined according to the primary endpoint of local recurrence following surgical treatment within two years and 5.0% of the noninferiority value. The assignment ratio of patients receiving SIE-NSM to C-OM was 1:3. If a one-sided level of significance of 0.025, 80% power, and an

estimated 10% drop-out rate was assumed, then the SIE-NSM and C-OM groups required a minimum recruitment threshold of 71 patients and 214 patients, respectively.

Data were described by mean $\pm$ standard deviation (consistent with normal distribution) or median (upper quartile, lower quartile) (inconsistent with normal distribution). Continuous variables of the SIE-NSM group and the C-OM group, including age, body mass index (BMI), tumor size, follow-up time, operative time, incision length, cosmetic effect score, upper extremity function score, and blood loss, were compared with two-sample independent t test (normal distribution) or Mann-Whitney U nonparametric test (non-normal distribution). Categorical variables, including local recurrence, tumor stage, hormone receptor status, subcutaneous effusion, and NAC necrosis rate, were described in absolute numbers and percentages and were compared using the Chi-square test between the two groups.

In addition, multivariable binary logistic regression was conducted to assess the risk of local recurrence for SIE-NSM vs C-OM and included age and tumor size as the covariates. The multivariable linear regression model was performed to evaluate the aesthetic outcome between the SIE-NSM and C-OM groups after adjusting for age and BMI. Similarly, multivariable linear regression model after adjusting for age was also conducted to explore upper extremity function of the two groups.

Results

Local recurrence and distant metastasis

Local recurrence occurred in one patient (1/71, 1.4%) in the SIE-NSM group and in two patients (2/214, 0.9%) in the C-OM group ($p = 0.735$). After local resection combined with chemotherapy and radiotherapy, these three patients were still alive at the end of the study's follow-up. In addition, multivariable binary logistic regression with age and tumor size as the covariates was conducted to assess the risk of local recurrence for SIE-NSM vs C-OM. There was no statistical difference in the local recurrence rate between the two groups [odds ratio = 2.683 (95% confidence interval: 0.21, 34.71, $p = 0.450$)] (Table 2). No distant metastasis was found in either group.

Table 2
Multivariable binary logistic regression of local recurrence

	Category	β	SE	Wald	OR (95%CI)	p -value
Group	C-OM group	Reference				
	SIE-NSM group	0.987	1.306	0.571	2.68 (0.21, 34.7)	0.450
Tumor size	Per 1 cm	1.978	1.044	3.590	7.23 (0.93, 55.99)	0.058
Age	Per 1 yr	-0.012	0.064	0.033	0.99 (0.87, 1.12)	0.855
SE: Standard error; OR: Odds ratio; CI: Confidence interval; C-OM: Conventional open mastectomy; SIE-NSM: Single-port insufflation endoscopic nipple-sparing mastectomy.						

BREAST-Q score

The SIE-NSM group had significantly superior BREAST-Q scores compared to the C-OM group in satisfaction with breasts (54.9 ± 6.2 vs 39.5 ± 8.6 , $p < 0.001$), chest well-being (92.5 ± 8.6 vs 82.2 ± 13.0 , $p < 0.001$), psychosocial well-being (78.0 ± 11.0 vs 58.2 ± 10.5 , $p < 0.001$), and sexual well-being (63.5 ± 9.9 vs 45.0 ± 8.3 , $p < 0.001$) (Table 3). The multivariable linear regression model was performed to evaluate the aesthetic outcome between SIE-NSM and C-OM after adjusting for age and BMI. The scores of various indicators in the SIE-NSM group were markedly better than those in the C-OM group ($p < 0.001$, Table 4).

Table 3
BREAST-Q¹ score

	SIE-NSM group	C-OM group	<i>p</i> -value
	(<i>n</i> = 71)	(<i>n</i> = 214)	
Satisfaction with breasts	54.9 ± 6.2	39.5 ± 8.6	< 0.001
Chest well-being	92.5 ± 8.6	82.2 ± 13.0	< 0.001
Psychosocial well-being	78.0 ± 11.0	58.2 ± 10.5	< 0.001
Sexual well-being	63.5 ± 9.9	45.0 ± 8.3	< 0.001
¹ BREAST-Q® VERSION 2.0 © Memorial Sloan Kettering Cancer Center and The University of British Columbia, 2017. SIE-NSM: Single-port insufflation endoscopic nipple-sparing mastectomy; C-OM: Conventional open mastectomy.			

Table 4
Multivariable linear regression of aesthetic outcome

Aesthetic, psychosocial, and sexual outcome	β	SE	T	p-value
Satisfaction with breasts				
Group (SIE-NSM <i>vs</i> C-OM)	15.808	1.121	14.105	< 0.001
Age	0.075	0.052	1.446	0.149
BMI	0.275	0.172	1.597	0.111
Chest well-being				
Group (SIE-NSM <i>vs</i> C-OM)	10.528	1.683	6.254	< 0.001
Age	0.051	0.078	0.656	0.512
BMI	0.264	0.258	1.023	0.307
Psychosocial well-being				
Group (SIE-NSM <i>vs</i> C-OM)	20.064	1.488	13.48	< 0.001
Age	0.053	0.069	0.765	0.445
BMI	0.319	0.228	1.397	0.164
Sexual well-being				
Group (SIE-NSM <i>vs</i> C-OM)	18.73	1.22	15.348	< 0.001
Age	0.028	0.057	0.501	0.617
BMI	0.266	0.187	1.418	0.157
SE: Standard error; SIE-NSM: Single-port insufflation endoscopic nipple-sparing mastectomy; C-OM: Conventional open mastectomy; BMI: Body mass index.				

Subjective value of upper extremity function

There was no statistically significant difference in the upper arm pain score between the two groups ($p = 0.162$). However, the SIE-NSM group had significantly better scores compared to the C-OM group in chest wall/breast pain (8.68 ± 1.19 *vs* 7.55 ± 1.12 , $p < 0.001$), shoulder range of motion (8.42 ± 1.41 *vs* 7.30 ± 1.12 , $p < 0.001$), and use of arm in daily life (8.44 ± 1.37 *vs* 7.23 ± 1.21 , $p < 0.001$) (Table 5). Multivariable linear regression model analysis after adjusting for age was conducted to explore upper extremity function of the two groups. There was no statistically significant difference in upper arm pain between the two groups. However, there was a significant difference between the SIE-NSM group and the C-OM group in chest wall/breast pain, shoulder range of motion, and use of arm in daily life ($p < 0.001$) (Table 6).

Table 5
Subjective value of upper extremity function

	SIE-NSM group	C-OM group	<i>p</i> -value
	(<i>n</i> = 71)	(<i>n</i> = 214)	
Pain upper arm	9.07 ± 1.06	8.87 ± 1.04	0.162
Chest wall/ breast pain	8.68 ± 1.19	7.55 ± 1.12	< 0.001
Shoulder range of motion	8.42 ± 1.41	7.30 ± 1.12	< 0.001
Use of arm in daily life	8.44 ± 1.37	7.23 ± 1.21	< 0.001
Extremity function was based on a scale of 1–10, where a score of 1 = poor function and a score of 10 = excellent function. The independent samples t-test was used to evaluate whether differences between the groups reached statistical significance. SIE-NSM: Single-port insufflation endoscopic nipple-sparing mastectomy; C-OM: Conventional open mastectomy.			

Table 6
Multivariable linear regression of upper extremity function

Upper extremity function scoring indicator	β	SE	T	<i>p</i> -value
Upper arm pain				
Group (SIE-NSM vs C-OM)	0.206	0.146	1.404	0.161
Age	0.001	0.007	0.157	0.876
Chest wall/ breast pain				
Group (SIE-NSM vs C-OM)	1.103	0.158	6.963	< 0.001
Age	-0.005	0.007	-0.739	0.461
Shoulder range of motion				
Group (SIE-NSM vs C-OM)	1.101	0.167	6.605	< 0.001
Age	-0.005	0.008	-0.703	0.483
Use of arm in daily life				
Group (SIE-NSM vs C-OM)	1.256	0.174	7.201	< 0.001
Age	0.013	0.008	1.636	0.103
SE: Standard error; SIE-NSM: Single-port insufflation endoscopic nipple-sparing mastectomy; C-OM: Conventional open mastectomy.				

Length of the incision, operative time, subcutaneous effusion, and blood loss

The length of the incision in the SIE-NSM group was significantly shorter than that in the C-OM group (3.66 ± 0.70 vs 15.0 ± 3.8 , $p < 0.001$), and the blood loss was also lower (24.8 ± 20.0 vs 39.7 ± 29.9 , $p < 0.001$). There were no cases of subcutaneous effusion in the SIE-NSM group, while the incidence rate of subcutaneous effusion in the C-OM group was 10.7%, which was statistically significant ($p = 0.004$). The operative time in the SIE-NSM group was markedly longer than in the C-OM group (205.6 ± 40.3 vs 116.5 ± 32.2 , $p < 0.001$) (Table 7).

Table 7
Length of the incision, blood loss, subcutaneous effusion and operative time

	SIE-NSM group	C-OM group	<i>p</i> -value
	(<i>n</i> = 71)	(<i>n</i> = 214)	
Length of the incision (cm)	3.7 ± 0.7	15.0 ± 3.8	< 0.001
Blood loss (mL)	24.8 ± 20.0	39.7 ± 29.9	< 0.001
Subcutaneous effusion	0 (0%)	23 (10.7%)	0.004
Operative time (min)	205.6 ± 40.3	116.5 ± 32.2	< 0.001
SIE-NSM: Single-port insufflation endoscopic nipple-sparing mastectomy; C-OM: Conventional open mastectomy.			

NAC ischemia and necrosis

In the SIE-NSM group, three (4.2%) patients developed grade 1–3 NAC ischemia (grade 0 = no ischemia, 1 = partial nipple or areolar ischemia, 2 = partial nipple and areolar ischemia, 3 = total nipple ischemia, 4 = total nipple and partial areolar ischemia, 5 = total nipple and areolar ischemia [13]), including one case each of grade 1, grade 2, and grade 3. According to the preoperative ICG angiography, all three cases had V1 type NAC blood supply. After conservative treatment, a scab and local depigmentation was evident in all three patients.

Discussion

The ongoing advancements in breast cancer screening detects more cases at earlier stages. Improved diagnostics have benefited breast cancer patients and complimented other therapy advancements by decreasing comprehensive treatment and easing the journey to remission/cure for many patients [14]. While patients recognize the importance of oncologic safety, they also demand (and deserve) management that facilitates social, psychosocial, and sexual well-being as well as maximal aesthetic outcome and functional recovery. This prompted breast cancer surgeons to consider methods that will improve patient quality of life with complete resection of the tumor(s).

Although breast-conserving therapy is typically the first choice to treat breast cancer, there are several cases where it is not recommended. Patients with diffuse lesions or multiple lesions or patients with a

small breast size (which is typical for Asian woman) will experience serious breast deformation if a breast-conserving surgery is performed [15]. The proportion of patients receiving breast-conserving therapy is generally lower in China than in Western countries [16, 17]. However, total mastectomy is also not a desirable choice for most Chinese patients [18]. The long, conspicuous scar and massive skin resection required by a total mastectomy negatively influences the postoperative aesthetic outcome and leads to upper extremity dysfunction that affects the patient's quality of life [19]. Due to sparing NAC and avoiding excessive skin resection, open NSM improved breast appearance after total mastectomy. Unfortunately, it has a high probability of NAC ischemia and necrosis [20] and an obvious scar in the chest wall. Therefore, it does not completely meet the aesthetic demand of patients.

Endoscopy-assisted NSM is often used to improve the postoperative aesthetic outcome. In our study, we introduced SIE-NSM in which two operations (axillary lymph node staging and mammary gland resection) were completed *via* a small, inconspicuous single-port incision in the axillary fossa, and a sufficient operation space was created by utilizing the insufflation method.

This study showed that there was no statistical difference in the local recurrence rate between the SIE-NSM group and C-OM group. However, we also observed a smaller tumor size and a lower age of patients in the SIE-NSM group. Therefore, we conducted multivariable binary logistic regression analysis using tumor size and age as covariates to assess the risk of local recurrence, and no statistically significant difference was found. This observation requires further prolonged follow-up and will be validated by an ongoing randomized controlled clinical trial (NCT04461847) of SIE-NSM *vs* C-OM conducted by our center.

We evaluated the aesthetic outcome and psychosocial well-being after operation with the BREAST-Q. Scores in the SIE-NSM group were all significantly better than those in the C-OM group. To adjust for age and BMI, multivariable linear regression model analysis was performed, and the SIE-NSM group still had significantly superior scores. We hypothesize several explanations for an increase in satisfaction with breasts and chest well-being: (1) a significantly shorter incision in the SIE-NSM; (2) no visible surgical scar on the chest because the single-port incision was hidden in the axillary fossa (Fig. 6); (3) SIE-NSM spared the NAC; and (4) due to small breast size, the loss of the mammary gland yet the sparing of the NAC only affected the symmetry of the breasts slightly. The significant improvement in satisfaction with breasts and chest well-being impacted the psychosocial well-being and sexual well-being in SIE-NSM group. This suggests that SIE-NSM improves the postoperative aesthetic outcome while also improving the psychosocial well-being and quality of life.

Upper extremity function is also an important factor influencing quality of life after mastectomy. C-OM requires the resection of a massive amount of chest skin and limits of movement of the upper extremity. Patients in the SIE-NSM group had less chest wall/breast pain, had a better range of motion in the shoulder, and had significantly superior use of their arms in daily life compared to the C-OM group. Because the patients in the SIE-NSM group were generally younger, a multivariable linear regression model analysis after adjusting for age was conducted. The results were similar. This indicated that SIE-

NSM reduced the traction of the chest wall scar to the upper extremity by preserving the integrity of the chest skin. Therefore, this improved upper extremity function and quality of life.

NAC ischemia and necrosis are common and serious complications after open NSM, and the highest incidence rate of ischemia was 64.1% [13]. NSM with an incision on the breast surface can damage the skin and subcutaneous vasculature of the breast, while the areolar incision can directly damage the NAC blood supply and lead to a high incidence rate of NAC ischemia and necrosis [21]. A recent study has shown that endoscopic NSM with an axillary incision can significantly decrease the incidence rate of NAC ischemia and necrosis [22]. In this study, only three SIE-NSM patients (4.2%) developed grade 1–3 NAC ischemia. No grade 4 or 5 (severe) NAC ischemia or necrosis was observed likely due to the incision in the axillary fossa, the deep nipple mammary duct was excised by laparoscopic scissors (reduced deep thermal damage caused by a harmonic scalpel or electrocautery), and the blood supply of the NAC and skin flap was assessed by ICG angiography before the operation [23, 24]. The blood supply to the NAC is classified by where the perfusion originates. Type V1 originates predominantly from the underlying breast tissue (Fig. 7A), type V2 originates from the surrounding skin (Fig. 7B), and type V3 is a combination of V1 and V2 (Fig. 7C). For type V1, when the mammary gland resection occurs, the vertical blood supply will be completely damaged, and ischemia and necrosis happen easily. The three patients with NAC ischemia had type V1. For these patients we avoided compression dressings and used nitroglycerin ointment because Gdalevitch *et al* [25] found that the use of nitroglycerin ointment could improve the blood supply to the skin flap and reduce necrosis in patients undergoing NSM and immediate reconstruction.

Subcutaneous effusion is a common complication after total mastectomy and can significantly influence the rehabilitation process. We observed that the incidence rate of subcutaneous effusion was 10.7% in the C-OM group and 0% in the SIE-NSM group. This observation can be explained by the following possible causes: (1) the heat from the electrotome used to dissect the skin flap in C-OM resulted in fat liquification, which increased the risk of subcutaneous effusion. The dissection of the skin flap in SIE-NSM was performed with laparoscopic scissors, which reduced the production of subcutaneous effusion; (2) liposuction during SIE-NSM greatly decreased the fat content in the breast and reduced the occurrence of fat liquification; and (3) after liposuction, the endoscopic amplification clearly displayed the membrane anatomy and ligaments around the mammary gland [10], which avoided damage to the membrane anatomy and reduced subcutaneous effusion.

In this study, blood loss was significantly lower in the SIE-NSM group compared to the C-OM group. This was due to the clear visualization of the membrane anatomy surrounding the mammary gland in SIE-NSM. The dissection was performed between the membrane anatomical structures, which reduced bleeding. Furthermore, the tumescent solution used preoperatively contained epinephrine, which could constrict the blood vessels and reduce blood loss. The operative time in the SIE-NSM group was longer than that in the C-OM group, likely due to the requirement of precise technique, which lengthens the operation time. The liposuction required to establish the operation space and expose the membrane anatomy lengthened the time as well.

Conclusion

This retrospective cohort study found that SIE-NSM is as safe as C-OM as shown by similar rates of local recurrence and distant metastasis for patients with early breast cancer who were unable or unwilling to receive breast reconstruction. In addition, SIE-NSM achieved better aesthetic outcomes, sexual well-being, psychosocial well-being, and upper extremity function. It also decreased the subcutaneous effusion rate and intraoperative blood loss. A randomized controlled clinical trial (NCT04461847) of SIE-NSM is underway to further observe the oncologic safety and aesthetic outcome of SIE-NSM in breast cancer patients unable or unwilling to undergo breast reconstruction.

Abbreviations

BMI

Body mass index

C-OM

Conventional open mastectomy

ICG

Indocyanine green

NAC

Nipple-areola complex

NSM

Nipple-sparing mastectomy

SIE-NSM

Single-port insufflation endoscopic nipple-sparing mastectomy

Declarations

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Conflicts of interest/Competing interests: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Ethics approval: This study was approved by the Ethics Committee of the Beijing Friendship Hospital, Capital Medical University (document number: 2019-P2-033-02) and were performed in line with the principles of the Declaration of Helsinki.

Consent to participate: All informed consent details were approved by the Ethics Committee of the Beijing Friendship Hospital, Capital Medical University (Beijing, China) (document number: document number: 2019-P2-033-02).

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Authors' contributions:

Zi-Han Wang and Wei-Hua Liu were responsible for manuscript writing. Zi-Han Wang and Xiang Qu were responsible for concept and protocol development. Shan-Shan Wu was responsible for statistical analysis. Yi-Ming Tian, Jun Liu, and Guo-Qian Ding were responsible for recruitment of study patients. Guo-Xuan Gao was responsible for the BREAST-Q score. Fang Xie was responsible for indocyanine green angiography. All authors were responsible for final approval of the manuscript and are accountable for all aspects of the work.

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Figures

Figure 1

The working space was created by the insufflation method with a single-port insufflation kit

Figure 2

The retromammary space was revealed after liposuction

Figure 3

The black arrow indicates Cooper's ligaments. The white arrow indicates the mammary gland

Figure 4

The membrane anatomy of the breast. The mammary gland is connected by different surrounding ligaments. Horizontal ligaments (white arrow) anchor the mammary gland (black arrow) directly to the fourth, fifth, and sixth ribs creating the inframammary fold

Figure 5

The entire mammary gland specimen was removed through the base part of the single-port insufflation kit

Figure 6

Comparison of the preoperative and postoperative photos. There was no scar visible on the chest wall. The only minor change was the nipple-areola complex lift (black arrow)

Figure 7

The blood supply to the nipple-areola complex can be visualized by ICG angiography. Type V1 originates predominantly from the underlying breast tissue (A), type V2 originates from the surrounding skin (B), and type V3 is a combination of V1 and V2 (C)