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ORIGINAL ARTICLE – BREAST ONCOLOGY

Robotic Nipple-Sparing Mastectomy and Immediate Breast Reconstruction with Gel Implant: Technique, Preliminary Results and Patient-Reported Cosmetic Outcome

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ABSTRACT

Background. Experience with application of a robotic surgery platform in the management of breast cancer is limited. The preliminary results of the robotic nipple-sparing mastectomy (R-NSM) and immediate breast reconstruction (IBR) with Gel implant procedure are reported.

Methods. The medical records of patients from a single institution who underwent an R-NSM and IBR with Gel implant procedure for breast cancer during the period March 2017 to February 2018 were assessed. Data on clinicopathologic characteristics, type of surgery, complications, and recurrence were analyzed to determine the effectiveness and oncologic safety of R-NSM. Patient-reported cosmetic outcome results were obtained.

Results. A total of 22 patients who received 23 R-NSM and IBR with Gel implant procedures were analyzed. The mean operation time for R-NSM was 118.8 ± 50.6 min, and 74.5 ± 26.6 min for Gel implant reconstruction. Docking time quickly dropped from 20 to 6–8 min, and the time needed to complete R-NSM was usually completed within 100 min after accumulation of case experience. Mean blood loss was 37 ± 38.2 mL, and the positive surgical margin rate was 0%. Three (13%) patients had transit nipple ischemia change, and no total nipple-areolar complex necrosis cases were observed. No local recurrence or mortality was found during a mean 6.9 ± 3.5 months of follow-up. All 22 patients were satisfied with the postoperative aesthetic outcome.

Conclusion. From our preliminary experience, R-NSM and IBR with Gel implant is a safe procedure, with good cosmetic results, and could be a promising new technique for breast cancer patients indicated for mastectomy.

Endoscopic-assisted nipple-sparing mastectomy (E-NSM) alone or followed by immediate breast reconstruction (IBR) with implants or autologous flaps was reported to be associated with small inconspicuous incisions and good cosmetic outcome.[1–7] Conventional E-NSM was performed with two separate incisions over the axilla and

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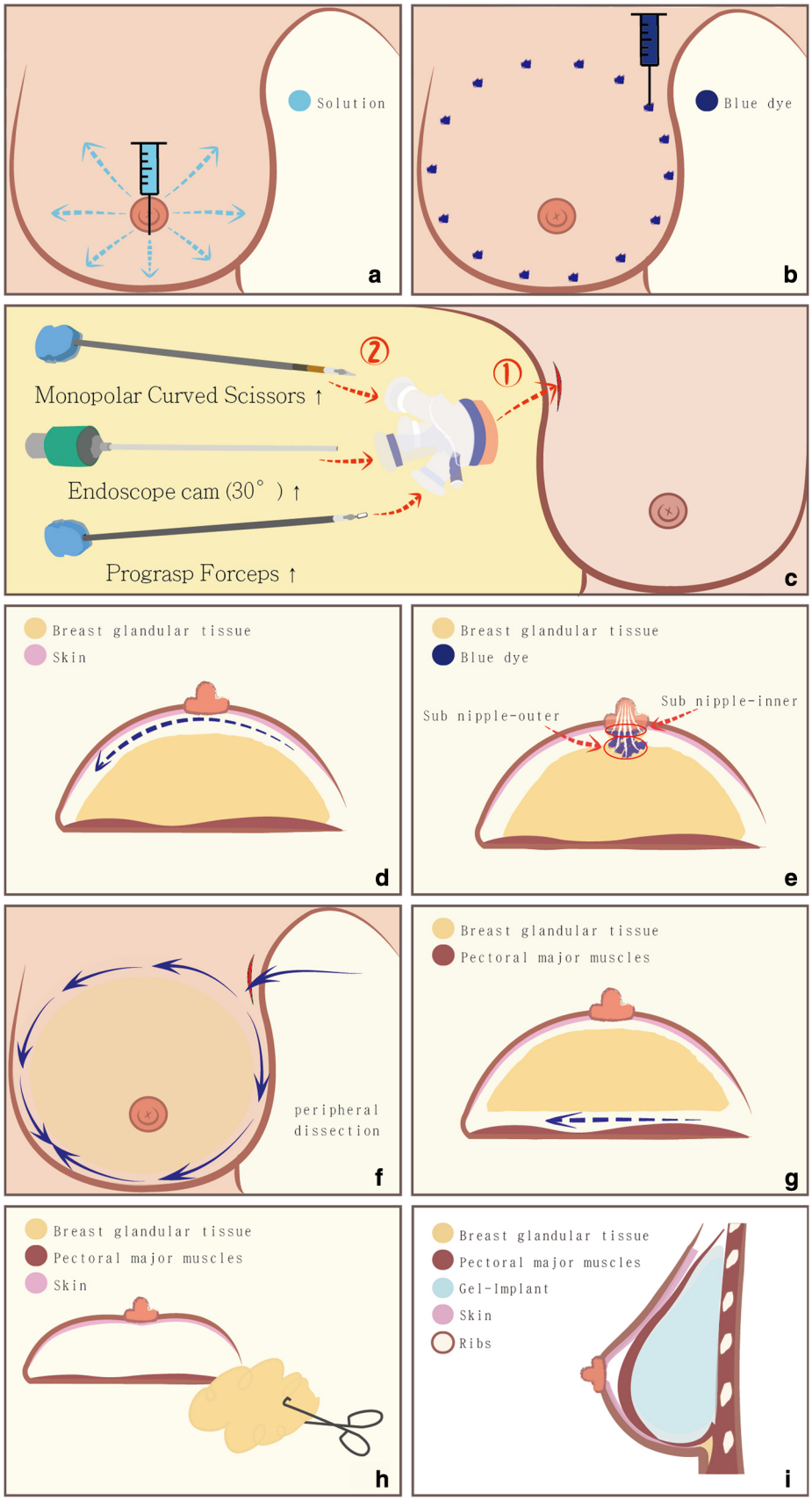
Solution
a
Blue dye
b
Monopolar Curved Scissors ↑
Endoscope cam (30°) ↑
Prograsp Forceps ↑
②
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c
Breast glandular tissue
Skin
d
Breast glandular tissue
Blue dye
Sub nipple-outer
Sub nipple-inner
e
peripheral
dissection
f
Breast glandular tissue
Pectoral major muscles
g
Breast glandular tissue
Pectoral major muscles
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Breast glandular tissue
Pectoral major muscles
Gel-Implant
Skin
Ribs
i

◀**FIG. 1** Cartoon pictures to depict robotic nipple-sparing mastectomy and immediate breast reconstruction with Gel implant. **a** Hydrodissection with subcutaneous injection of saline solution (containing adrenaline and lidocaine) was performed in the whole breast to minimize bleeding. A physiological saline solution containing lidocaine 0.05% and epinephrine 1:1,000,000 was used in the current study. **b** Injection of jelly containing methylene blue as a guide to mark the boundary of resection. **c** Insertion of a single port, and robotic surgical platform with the da Vinci Si system (video camera, monopolar scissor, and ProGrasp forceps). **d** Subcutaneous skin flap dissection was performed by dissection between the skin flaps and breast glandular tissue. The septa between the skin flap and parenchyma were dissected using monopolar scissors. **e** Intraoperative sub-nipple biopsy was performed by taking two separate specimens (inner and outer part) under the nipple-areolar complex, which were sent for frozen section pathologic analysis. **f** Peripheral dissection was performed using ProGrasp forceps and monopolar scissors for dissection of breast tissue, and detached from the peripheral skin flap and chest wall. **g** Posterior subglandular dissection was performed using ProGrasp forceps and monopolar scissors for dissection of the plane between the pectoral muscle fascia and deep (inferior) part of the breast parenchyma. The penetrating vessels were coagulated and cut with monopolar scissors to ensure a clear visual field and to maintain hemostasis. **h** After completion of all the dissections, the entire breast specimen was removed through the axillary wound. **i** Breast reconstruction was performed with dissection of the subpectoral muscular pocket, which was formed by the pectoralis major, serratus anterior, and fascia of the external oblique muscle, using ProGrasp forceps and monopolar scissors. The Gel implant was inserted from the axillary wound and placed in the muscular pocket

peri-areolar regions.[1,3,4,7] New technique modifications of E-NSM are emerging, focusing on single-axillary incision NSM,[2,8,9] which spares the peri-areolar incision and thereby decreases the compromise of blood supply from the mastectomy skin flap, and was reported to have a low nipple areolar complex (NAC) necrosis rate (0%).[2,8,9]

Endoscopic single-axillary E-NSM,[2,8] which used a single port and endoscopic instruments to perform NSM with or without IBR, was successful in decreasing NAC ischemia necrosis and optimizing cosmetic outcome by reducing wound length; the wound was hidden in an inconspicuous region. However, the two-dimensional endoscopic in-line camera produces an inconsistent optical window around the curvature of the breast skin flap. Furthermore, internal mobility was limited and the dissection angles were inadequate, with traditional endoscopic rigid tip instruments through a single access.[2,8] Due to the limitations of the endoscopy instruments, and technique difficulty, neither conventional nor single-access E-NSMs are widely used in breast cancer patients.[10,11]

Robotic surgery, which incorporates a three-dimensional imaging system, as well as flexibility of the robotic arm and instruments, has been increasingly used in different fields of surgeries.[12–14] Robotic nipple-sparing mastectomy (R-NSM),[9,15–17] which introduces the da Vinci surgical platform through a small axillary wound to perform NSM with or without IBR, was reported to have the potential to overcome the technique difficulty of E-NSM, and showed promising cosmetic outcome.

In this study, we report on the preliminary experience and clinical outcome of the R-NSM and IBR with Gel implant procedure in breast cancer patients. The technique, perioperative morbidity, preliminary oncologic safety, and patient-reported cosmetic outcomes were analyzed and reported.

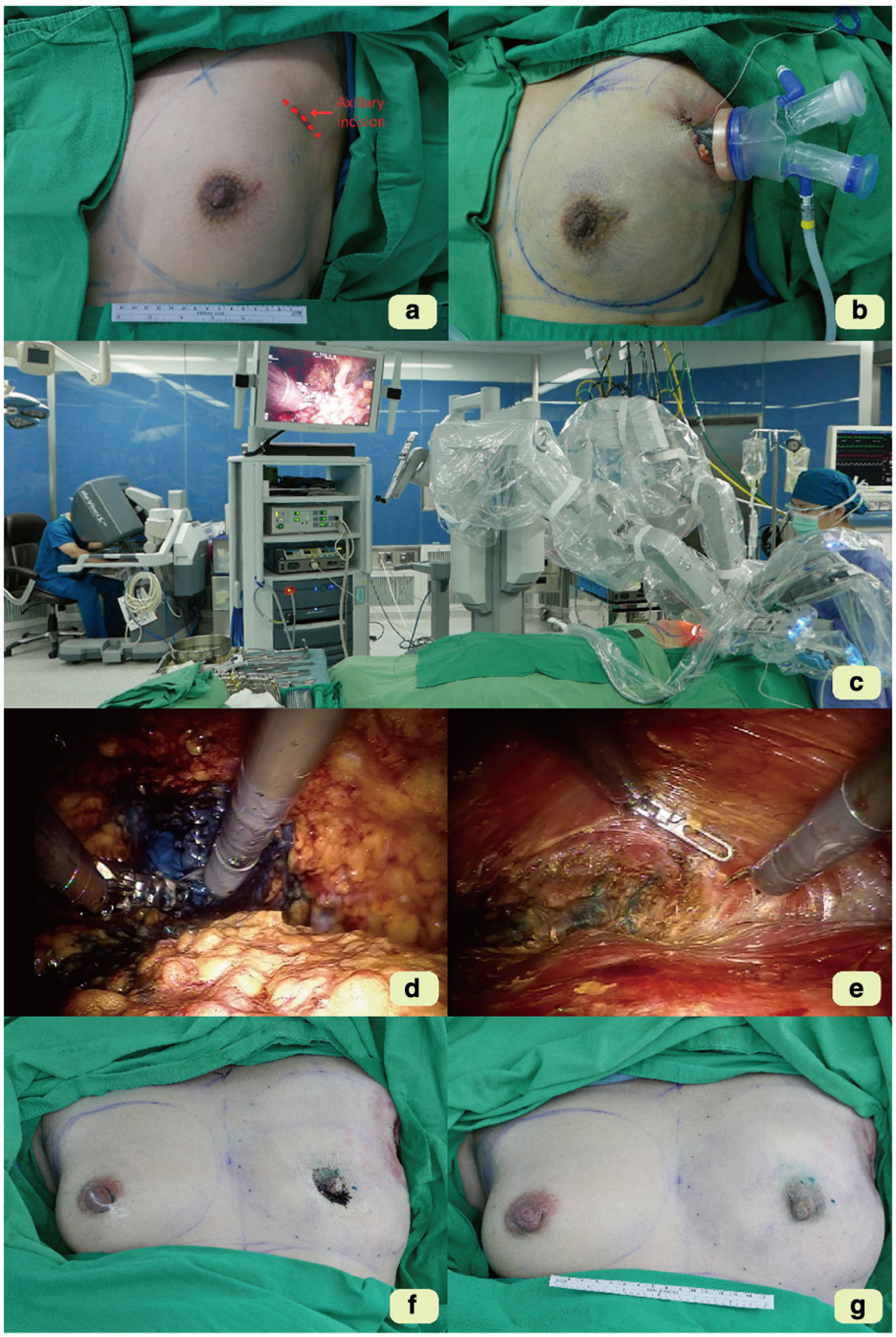
MATERIALS AND METHODS

Patients

Patients who received robotic breast surgeries from March 2017 to February 2018 were searched from our robotic breast surgery database at Changhua Christian Hospital (CCH), a tertiary medical center in central Taiwan. During the study period, a total of 31 robotic breast surgery procedures were performed in 28 female patients with breast cancer, including 3 patients with bilateral disease. Among these 31 robotic breast procedures, 29 were R-NSM related. Two patients with bilateral breast cancer received bilateral R-NSM without breast reconstruction. Twenty-five R-NSM cases were associated with IBR. Two patients received R-NSM and IBR with robotic-assisted harvesting of the latissimus dorsi flap, and 22 patients received 23 R-NSM and IBR with Gel implant procedures. These 22 patients were enrolled in the current study and their data analyzed.

This study was approved by the Institutional Review Board (IRB) of the CCH (CCH IRB No. 170806). Written informed consent for the use of clinical records was obtained from all participants. This current study includes photos of several patients, all who had agreed to, and signed consent for, publication of their photos. The data reported in the current analysis also included the patient data reported in an earlier publication.[18]

Indications for R-NSM included early-stage breast cancer (ductal carcinoma in situ [DCIS], stage I, II or IIIA), tumor size < 5 cm, no evidence of multiple lymph node metastasis, and no evidence of nipple, skin or chest wall invasion. Patients for whom R-NSM was contraindicated included those with apparent NAC involvement, inflammatory breast cancer, breast cancer with chest wall or skin invasion, locally advanced breast cancer, breast cancer with extensive axillary lymph node metastasis (stage IIIB or later), and patients with severe comorbid conditions, such as heart disease, renal failure, liver dysfunction, and poor performance status as assessed by the primary physicians. Women with large breasts (cup size larger than E, or breast mastectomy weight > 600 g) and breast ptosis



are not good candidates for the R-NSM and IBR with Gel implant procedure due to the difficulty of the technique and suboptimal cosmetic outcome. The inclusion and exclusion criteria were based on the criteria previously reported.[5–8,18,19]

Perioperative morbidity and the oncologic safety of R-NSM were carefully monitored. Surgical margin involvement was defined as tumor on ink.[20] Postoperative adjuvant hormone therapy, chemotherapy, and radiotherapy were administered to patients according to current breast cancer guidelines.[21,22] The total incidence of recurrence or death due to breast cancer was ascertained at the most recent follow-up, which ended on 31 March 2018.

Robotic Nipple-Sparing Mastectomy (R-NSM) Technique

The R-NSM technique used in the current study has been illustrated with cartoons (Fig. 1) and photos (Fig. 2).[18] The patient was placed in the supine position

◀**FIG. 2** Operative photos taken for representative techniques for robotic nipple-sparing mastectomy and immediate breast reconstruction with Gel implant. **a** An approximately 2.5–4 cm oblique axillary incision was made for lymph node surgery and insertion of a port. The axillary skin incision length depended on the size of the breast to be removed and the size of the Gel implant to be inserted. From our experience, when a breast specimen weighs < 300 g (approximate breast cup size B), a 3.5 cm wound was usually sufficient; a breast specimen weighing 400 or 500 g (approximate breast cup size C or D) would require a 4 or 5 cm wound to retrieve the specimen. **b** After creation of the working space, the single port (Glove Port) was inserted over the operating axilla, and carbon dioxide (CO_2) inflation with air pressure was kept at 8 mmHg to create space for mastectomy. **c** The robotic side cart (da Vinci) is positioned posterior to the patient, with the two robotic arms and the endoscope extending over the patient in proximity to the ports. In this position, the arms are aligned with the plane of the breast, nearly parallel to the floor, and the ports are docked to the robotic arms. To prevent conflict during dissection, the elbows of robotic arms were opened as much as possible. **d** Anterior skin flap dissection was performed by dissection between the skin flaps and breast glandular tissue using the monopolar scissors. Intraoperative sub-nipple biopsy was performed by taking two separate specimens (inner and outer parts) under the nipple-areolar complex, which were then sent for frozen section pathologic analysis. **e** After mastectomy, the specimen was removed from the axillary wound, and the submuscular pocket, which was formed by the pectoralis major, serratus anterior, and fascia of the external oblique muscle, was then dissected for prosthesis breast reconstruction. The ProGrasp forceps were used to lift the pectoralis major muscles, and monopolar scissors were used for dissection of the submuscular space. By using the single port with one-way gas inflation and gas deflation in the opposite direction, a circulation air flow zone is created, which efficiently drains the smoke created when using monopolar scissors during dissection. **f** Immediately post-mastectomy before reconstruction, the wound was small and was hidden in the inconspicuous axilla region. **g** Immediate post-breast reconstruction outcome result, front view. The cohesive Gel implant (or tissue expander when indicated) used for breast reconstruction was inserted from the axillary wound and left in the subpectoral muscular pocket. Two drains were usually left (one beneath the skin flap and the other over the submuscular pocket). The drains were removed during the outpatient clinic follow-up, within 2 weeks postoperation

and the arm was abducted 90°. An approximately 2.5–4 cm oblique axillary incision was then made over the extra-mammary region (Fig. 2a) and sentinel lymph node biopsy (or lymph node dissection) was performed if indicated.

Robotic Docking and Dissection

To create the working space for the placement of the single port (Glove Port; Nelis Corporation, Gyeonggi-do, Korea) [Figs. 1c, 2b], a 3–4 cm subcutaneous flap was dissected with electrocautery under direct vision. The tunneling technique[5,6,8,18,19] was used to facilitate the breast skin flap dissection and create space between the skin flap and the breast parenchyma. The single port was then inserted from the axilla, and carbon dioxide (CO_2) was inflated with air pressure kept at 8 mmHg to create space for mastectomy (Fig. 2b).[9,15,18] The operating side shoulder was elevated to 30° with draping to prevent conflict between the operating table and docking of the robotic surgery system.[15,17,18] The robotic side cart (da Vinci; Intuitive Surgical, Sunnyvale, CA, USA) was then positioned posterior to the patient, with the two robotic arms and the endoscope extending over the patient in proximity to the ports, and the ports docked to the robotic arms (Fig. 2c).

The operation was then shifted to a da Vinci Si (Intuitive Surgical, Sunnyvale, CA, USA) robotic platform controlled by the operating surgeon at the console (Fig. 2c). All R-NSM cases reported in the current study were carried out by the same surgeon (HWL). We used a 30° 12 mm diameter camera (Intuitive Surgical, Denzlingen, Germany) in the upper port to prevent collisions with other instruments. Dissection was carried out using 8 mm monopolar scissors (Intuitive Surgical, Sunnyvale, CA, USA). Traction and counter-traction, along with maintaining exposure and stretching out the tissue, was carried out using 8 mm ProGrasp forceps (Intuitive Surgical, Sunnyvale, CA, USA) [Fig. 1c]. The location of the scissors and the ProGrasp forceps in either the right or left arm could be adjusted during operation.

Dissection started from the superficial skin flaps (Fig. 1d), and the septa between the skin flap and parenchyma created by the tunneling technique[5,6,8,18,19] was cut with monopolar scissors. After dissection of the skin flap from the breast parenchyma, the space increased gradually after the connection between the skin flap and the breast parenchyma was divided piece by piece. A sub-nipple biopsy was then performed under NAC (Figs. 1e, 2d) and the intraoperative frozen section was analyzed.[23] If cancer cell invasion was found in the sub-areolar area, the entire NAC was removed. After completion of the superficial skin flap dissection, the peripheral and posterior dissection was carried out by pulling the breast tissue to create a sufficient working space (Fig. 1f, g). Posterior dissection was performed by detaching the breast tissue from the pectoralis major muscle, and perforators were clearly identified. After completion of dissection, the entire breast specimen was removed through the axillary wound (Fig. 1h) as a single piece; we did not remove the specimen in segments in order to prevent inadequate pathologic analysis.

Breast Reconstruction

Subpectoral working space was developed under direct vision by electrocautery with assistance of a handle light retractor. The single port was then re-inserted and gas re-inflated for robotic submuscular pocket dissection using a da Vinci surgical platform (Fig. 2e). After initial dissection

of the submuscular space with the da Vinci surgical platform, the robotic instruments and single port were removed. The operating table was then bent into the sitting position. The adequacy of the submuscular pocket dissection was checked and completed with the assistance of a light source retractor. After creation of the submuscular pocket, the implant was inserted from the axillary access (Figs. 1i, 2g). A video of the R-NSM and IBR with Gel implant procedure has been provided as an electronic supplementary file.

Aesthetic Outcome Evaluation

Postoperative aesthetic outcome was evaluated by comparing the pre- and postoperative cosmetic results (Figs. 3a–f). A self-reported questionnaire, comprising 10 questions designed for patients who received R-NSM and IBR with Gel implant, was conducted 1–3 months after the operation, to evaluate the aesthetic outcome and patients' satisfaction (Table 3).

Preliminary Learning Curve Evaluation of R-NSM

To evaluate the impact of case experience accumulation on the operation time of the R-NSM and IBR with Gel implant procedure, the overall operation time, time spent docking, R-NSM, and specimen weight were gathered and plotted in case sequence (Fig. 3g).

Statistical Analyses

Differences in continuous variables were tested using the independent *t* test and are reported as mean ± standard deviation (SD). The χ^2 test was used for categorical comparisons of data when appropriate. A p value < 0.05 was considered to indicate statistical significance, and all tests were two-tailed. All statistical analyses were performed using the SPSS statistical package version 19.0 (IBM Corporation, Armonk, NY, USA).

RESULTS

During the study period, 22 patients with breast cancer received 23 R-NSM and IBR with Gel implant procedures (one patient had bilateral breast cancer). Patient demographic and clinical characteristics are summarized in Table 1. Intraoperative sub-nipple biopsy was performed in 21 (91.3%) of the R-NSM procedures. The mean operation time for R-NSM was 118.8 ± 50.6 min, and 74.5 ± 26.6 min for Gel implant breast reconstruction, and mean blood loss was 37 ± 38.2 mL (Table 2). Three (13%) patients suffered from transient partial nipple ischemia but recovered after conservative treatment. No total NAC necrosis or implant loss was observed (Table 2), and no surgical margin involvement was observed in the final pathologic check-up. During a mean follow-up of 6.9 ± 3.5 months, no locoregional recurrence was observed.

The postoperative outcome of R-NSM is shown in Figs. 3a–f, and all patients completed the postoperative cosmetic outcome questionnaire (Table 3). Nearly all patients were satisfied with the appearance of the postoperative scar, as well as wound length and wound position. In the overall score regarding cosmetic outcome evaluation, approximately 82.3% (19/23) of patients were graded as excellent, and 17.4% (4/23) were graded as good (Table 3). Figure 3g clearly demonstrates that the time for docking of the da Vinci Si robotic surgery system quickly dropped from 20 min to 6–8 min. The time needed for R-NSM fluctuated mainly with the specimen weight, and, with the accumulation of case experience, the time for R-NSM quickly dropped to within 100 min.

DISCUSSION

In our preliminary 29 R-NSM cases, no cases of robotic procedure had to be converted to standard mastectomy. Positive lymph nodes were not a contraindication for robotic mastectomy. Lymph node dissection could be performed at the same incision. We observed a low amount of blood loss (mean 37 ± 38.2 mL) [Table 2]. The air pressure (8 mmHg) derived from inflation of CO_2 might contribute to the reduction of bleeding, and decrease secretion from the tissue. Distension of the breast skin flap after inflation of CO_2 also created sufficient working space and this could spare the assistant for skin retraction (Fig. 2b, c). However, subcutaneous emphysema was also observed as a sequel after gas inflation. Fortunately, the subcutaneous emphysema usually subsided spontaneously without causing morbidity, after operation.

Among our 23 R-NSM and IBR with Gel implant procedures, there were no cases of complete NAC necrosis or large areas of skin flap necrosis (Table 2). This extremely low rate of NAC and skin flap ischemia necrosis is promising and may be related to several factors. First, R-NSM only uses one single-axillary incision, and spares the peri-areolar incision, which was associated with an increased NAC ischemia necrosis rate of 7–81.8%.[5,24–26] Furthermore, the robotic optical window, which was three-dimensional, and delicate instruments allowed the intercostal perforator to be readily recognized and saved, which contributed significantly to the overall circulation of both the NAC and the mastectomy flaps.[9,15] The low NAC ischemia/necrosis characteristics of robotic surgery could

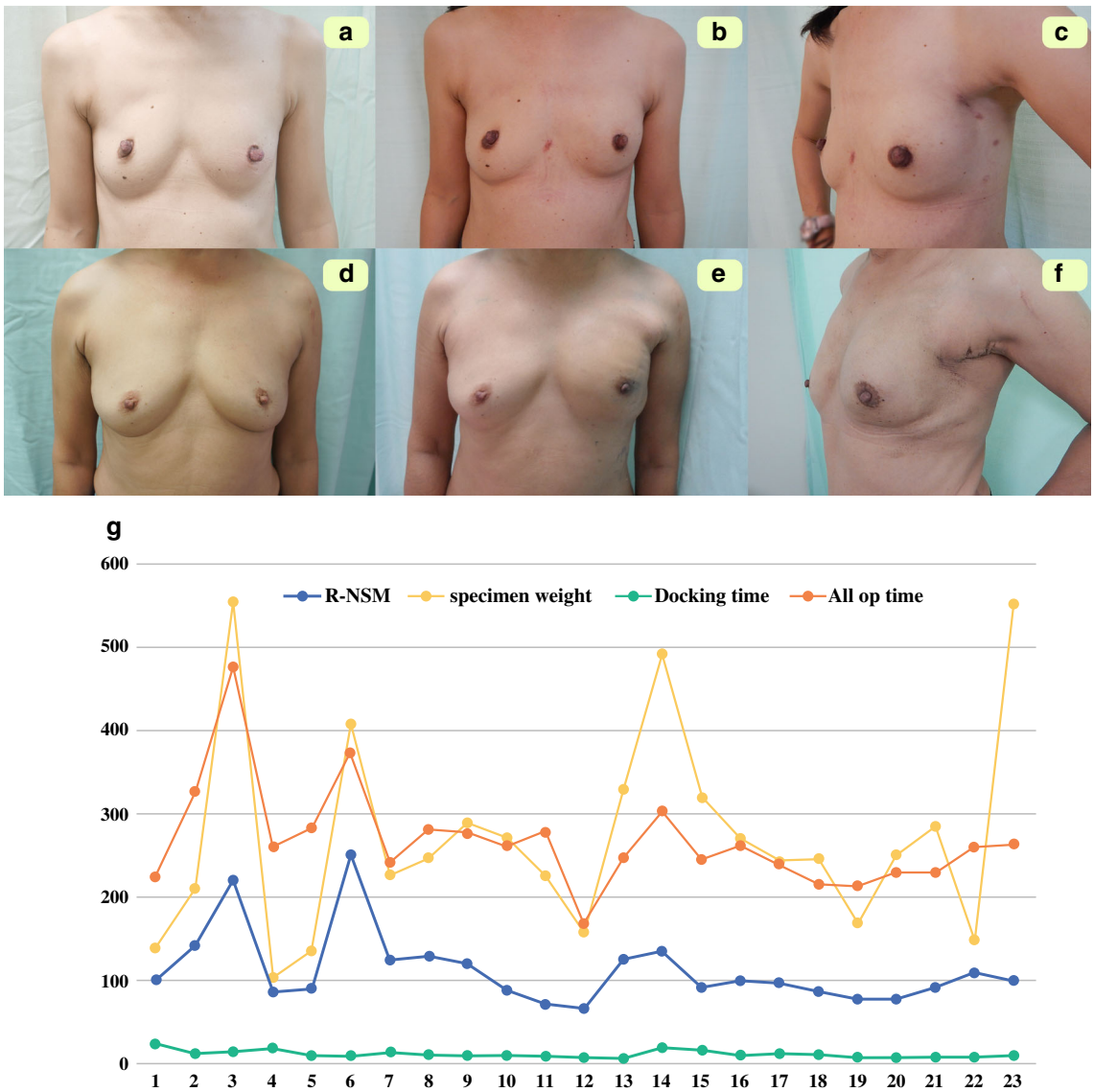


FIG. 3 Pre- and postoperative photos for patients receiving R-NSM and IBR with Gel implant. **a** Preoperative front view of a 49-year-old female with left breast ductal carcinoma in situ prepared for operation. The patient underwent left SLNB, and R-NSM and IBR with Gel implant. **b** Postoperative front view of the patient showing bilateral breast symmetry. The left breast nipple was well perfused, without sign of ischemia, and the wound was well hidden over the axilla. **c** Postoperative lateral view showing that the wound was small and well hidden in the inconspicuous axilla region. **d** Front view of a 59-year-old female with cancer of the left breast. R-NSM and SLNB were performed. Frozen biopsy revealed metastatic carcinoma, and axillary lymph node dissection was performed. Left R-NSM and IBR with Gel implant was performed. **e** Front view of the patient 3 months' postoperation, revealing bilateral breast symmetry. The nipple was well perfused, without sign of ischemia, and the wound was well hidden over the axilla. **f** Left lateral view, taken 11 months postoperation and after completion of a course of radiotherapy, showing that the wound was small and well hidden in the inconspicuous axillary region. **g** Relation of operation time and case experience accumulation in R-NSM and IBR with Gel implant. The 'time for docking' was defined as the time from the start of the insertion of a single port to completion of the set-up of a da Vinci surgical platform. The 'time for R-NSM' was defined as the time from set-up of a robotic surgical platform and starting skin flap dissection with monopolar scissors to the completion of robotic mastectomy and removal of the mastectomy specimen. The 'time for breast reconstruction' was defined as the time from removal of the mastectomy specimen to completion of the Gel implant insertion. The 'overall operation time' was defined as the time from the start of the skin incision to the end of the wound closure. The 'specimen weight' was the weight of the removed mastectomy specimen. *R-NSM* robotic nipple-sparing mastectomy, *IBR* immediate breast reconstruction, *SLNB* sentinel lymph node biopsy

TABLE 1 Clinicopathologic characteristics of 23 robotic nipple-sparing mastectomy and immediate breast reconstruction with Gel implant procedures [*N* = 23]

Age, years [mean ± SD (range)]	48.9 ± 11.6	(28.8–71.6)
Location		
Right	13	(56.5)
Left	10	(43.5)
Sonogram tumor size, cm [mean ± SD (range)]	2.8 ± 1.2	(1.2–5.6)
Pathology tumor size, cm		
Invasive [mean ± SD (range)]	1.9 ± 1.2	(0.1–3.8)
In situ [mean ± SD (range)]	1.7 ± 1.2	(0.7–3.0)
Multicentric/multifocal lesion		
Yes	4	(17.4)
No	19	(82.6)
Clinical stage [NA = 3]		
Tis	5	(21.7)
I	3	(13.0)
IIA	9	(39.1)
IIB	2	(8.7)
IIIA	1	(4.3)
Pathologic stage [NA = 2]		
Tis	4	(17.4)
I	7	(30.4)
IIA	5	(21.7)
IIB	3	(13.0)
IIIA	2	(8.7)
Lymph node metastasis		
No	14	(60.9)
Yes	9	(39.1)
Lymph node stage		
N0	14	(60.9)
N1	7	(30.4)
N2	2	(8.7)
Margin status		
Not involved	23	(100)
Involved	0	(0)
Grade [NA = 6]		
I	6	(26.1)
II	8	(34.8)
III	3	(13.0)
ER [NA = 3]		
Positive	19	(82.6)
Negative	1	(4.3)
PR [NA = 3]		
Positive	10	(43.5)
Negative	10	(43.5)
HER2 [NA = 6]		
Overexpression	2	(8.7)
Negative	15	(65.2)
Ki-67 [NA = 7]		
< 14%	11	(47.8)
> 14%	5	(21.7)
Lymph node surgery		
SLNB only	15	(65.3)
SLNB then ALND	5	(21.7)
ALND	1	(4.3)
No surgery	2	(8.7)
Breast reconstruction		
Yes	23	(100.0)
No	0	(0.0)
Adjuvant treatment		
Endocrine therapy		
Yes	18	(78.3)
No	5	(21.7)
Chemotherapy		
Yes	9	(39.1)
No	14	(60.9)
Radiotherapy		
Yes	6	(26.1)
No	17	(73.9)

Data are expressed as *n* (%) unless otherwise specified

NA not available, *ER* estrogen receptor, *PR* progesterone receptor, *HER2* human epithelial growth factor receptor 2, *SLNB* sentinel lymph node biopsy, *ALND* axillary lymph node dissection, *SD* standard deviation

be suggested for patients who had substantial risk for NAC necrosis, such as history of diabetes mellitus or previous radiation history, and were indicated for NSM.[24–26]

All except two patients, who received R-NSM for subsequent contralateral prophylactic mastectomy, received intraoperative sub-nipple biopsy. For patients selected for NSM, the risk of occult breast cancer in NAC (9–19%) remained unneglectable,[23] and sub-nipple biopsy was able to detect occult cancer invasion of the NAC. From the experience of our preliminary cases, the robotic surgical platform with the da Vinci Si system worked efficiently in performing sub-nipple biopsy.[18] We were able to remove most breast glandular tissue near and beneath the NAC, and coring sub-nipple lactiferous ducts, to minimize the risk of local recurrence (Fig. 2d).

The robotic surgical platform was successfully applied in the field of breast reconstruction,[9,14,15,18,27] either in harvesting of the autologous latissimus dorsi flap[14,27] or in dissection of the submuscular pocket for insertion of the prosthesis.[9,15,18] In the current series, all implants were placed subpectorally. Placement of the prosthesis in the prepectoral plane is a new concept of breast reconstruction that was reported to have promising cosmetic results,

TABLE 2 Clinical outcome of robotic nipple-sparing mastectomy and immediate breast reconstruction with Gel implant procedures [$N = 23$]

All operation times, minutes [mean ± SD (range)]	279.8 ± 79.3		(169–500)
Mean mastectomy time, minutes [mean ± SD (range)]	118.8 ± 50.6		(66–250)
Mean reconstruction time, minutes [mean ± SD (range)]	74.5 ± 26.6		(40–126)
All blood loss, mL [mean ± SD (range)]	37.0 ± 38.2		(20–200)
Specimen weight, g [mean ± SD (range)]	284.3 ± 125.2		(105–553)
Gel implant size, mL [mean ± SD (range)]	324.4 ± 82.9		(130–500)
Hospital day [mean ± SD (range)]	6.7 ± 1.3		(5–9)
	Group 1 (case numbers 1–12)	Group 2 (case numbers 13–23)	*p* value
All operation times, minutes	287.3 ± 77.4	270.7 ± 84.8	0.638
Mean mastectomy time, minutes	134.5 ± 63.8	101.7 ± 23.46	0.123
Mean reconstruction time, minutes	79.3 ± 27.9	69.2 ± 25.5	0.373
Complications			
Delayed axillary wound healing	1	(4.3%)	
Skin flap blister formation	1 (small area)	(4.3%)	
Skin flap ischemia/necrosis	1 (small area)	(4.3%)	
Transient nipple ischemia	3	(13%)	
Total nipple-areolar complex necrosis	0	(0%)	
Implant loss	0	(0%)	
Mean follow-up, months	6.9 ± 3.5	(1.7–12.7)	
Locoregional recurrence			
Yes	0	(0%)	
No	23	(100%)	
Distant metastasis			
Yes	0	(0%)	
No	23	(100%)	
Mortality			
Yes	0	(0%)	
No	23	(100%)	

decreasing muscular dissection and related injury.[28,29] Placement of the prosthesis in the prepectoral plane might be a feasible and safe option for patients receiving R-NSM as the risk of skin flap ischemia/necrotic complication is so low.

The current study also collected patient-reported cosmetic outcomes for the R-NSM and IBR with Gel implant procedure, which, to our knowledge, was the first report for R-NSM. The results of patient-reported cosmetic outcomes supported the fact that this new type of operation is associated with good aesthetic result (Table 3). Furthermore, 95.5% of patients would choose the same operation if they were to make their decision again, which showed that the R-NSM and IBR with Gel implant procedure is highly accepted by patients.

The two main limitations of R-NSM were the longer operation time and the higher cost of robotic surgery. We observed that 10–12 cases were needed to decrease the robotic mastectomy time (Fig. 3g, Table 2), and, after that, R-NSM could usually be completed within 100 min, which was close to the conventional NSM operation time. There is inevitable increase in cost when performing R-NSM compared with conventional mastectomy. According to our estimation, it would cost US $10,000–12,000 to perform an R-NSM and IBR with Gel implant procedure. The cost of using the da Vinci surgical platform varied according to different institutions; however, in our institution, approximately US $6000 per use was required. Nonetheless, the cost effectiveness of robotic surgery in the management of breast disease remains to be analyzed.

TABLE 3 Patient-reported cosmetic outcome result for 22 patients with 23 robotic R-NSM and IBR with Gel implant procedure

	Unsatisfied (%)	Fair (%)	Satisfied (%)	Very satisfied (%)	
Q1. Preoperative breast appearance satisfaction	1 (4.3)	0 (0.0)	13 (56.5)	9 (39.2)	3.3 ± 0.8
Q2. Postoperative breast appearance satisfaction – with dressing	0 (0.0)	0 (0.0)	7 (30.4)	16 (69.6)	3.7 ± 0.6
Q3. Postoperative breast appearance satisfaction – no dressing	0 (0.0)	2 (8.7)	10 (43.5)	11 (47.8)	3.4 ± 0.7
Q4. Postoperative bilateral breast size satisfaction	0 (0.0)	4	(17.4)	8 (34.8)	11 (47.8)
3.3 ± 0.7					
Q5. Postoperative bilateral breast symmetry satisfaction	0 (0.0)	4	(17.4)	10 (43.4)	9 (39.2)
3.2 ± 0.7					
Q6. Postoperative nipple-areola position satisfaction	0 (0.0)	0 (0.0)	12 (52.2)	11 (47.8)	3.5 ± 0.5
Q7. Scar appearance satisfaction	0 (0.0)	1 (4.3)	7 (30.4)	15 (65.3)	3.6 ± 0.6
Q8. Scar length satisfaction	0 (0.0)	0 (0.0)	7 (30.4)	16 (69.6)	3.7 ± 0.6
Q9. Surgical wound position satisfaction	0 (0.0)	0 (0.0)	7 (30.4)	16 (69.6)	3.7 ± 0.7
Q10. Are you willing to undergo robotic nipple-sparing mastectomy if you could chose again?	Yes	21	(95.5)		
Not sure	1 (4.5)				
Overall satisfaction	Poor	Fair	Good	Excellent	
Range	8–11	12–19	20–27	28–32	
	0 (0.0)	0 (0.0)	4 (17.4)	19 (82.6)	

The self-reported questionnaire comprised 10 questions, and 4 itemized scales (graded as '1, unsatisfied', '2, fair', '3, satisfied', and '4, 'very satisfied') were rated in each question. To evaluate the overall satisfaction of R-NSM and IBR with Gel implant, the overall score of questions 2–9 in each patient was summarized. Those with an overall score of 8–11 were graded as poor, a score of 12–19 was graded as fair, a score of 20–27 was graded as good, and a score of 28–32 was graded as excellent. Patients with results graded as 'excellent' or 'good' were defined as being satisfied with the cosmetic outcome

R-NSM nipple-sparing mastectomy, *IBR* immediate breast reconstruction

CONCLUSIONS

From our preliminary experience, R-NSM and IBR with Gel implant is a safe procedure, with good cosmetic results, and could be a promising new technique for breast cancer patients indicated for mastectomy. Women with small- to medium-sized breasts, node negative, and tumor located in the upper outer quadrant, with adequate skin to tumor distance (> 3 mm), are good candidates for R-NSM.

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