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ORIGINAL ARTICLE
Breast

Changes in Skin Paddle Morphology after Autologous Breast Reconstruction

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Background: Immediate autologous breast reconstruction (IABR) can provide favorable aesthetic outcomes after skin-sparing mastectomy. However, it is known that the morphology of the reconstructed breast changes over time. Therefore, it is necessary to be able to predict the likely amount of change preoperatively to reconstruct a symmetrical breast. In this study, we retrospectively examined the change in position and morphology of the skin paddle of the reconstructed breast over time.
Methods: Thirty-five patients who underwent IABR after skin-sparing mastectomy for unilateral breast cancer were included. Three-dimensional images were obtained at 1 month and 12 months postoperatively to compare changes in the position and size of the skin paddle over time.
Results: Significant increases were observed in the distance between the center of the skin paddle and the midpoint of the clavicle, the distance between the center of the skin paddle and the sternal notch, and projection. No significant change was observed in the distance between the inframammary fold and the center of the skin paddle. There was a significant increase in the area and short axis of the skin paddle.
Conclusions: Our main findings were that the skin paddle shifts toward the outer caudal side after IABR and tends to become larger. When planning delayed nipple reconstruction with a local flap designed on a skin paddle, the paddle should be positioned slightly more mediocranially than the healthy nipple and should be narrower. *(Plast Reconstr Surg Glob Open 2024; 12:e6175; doi: 10.1097/GOX.0000000000006175; Published online 19 September 2024.)*

INTRODUCTION

Breast reconstruction using autologous tissue transplantation after total or partial mastectomy is now widely used as a standard procedure for breast cancer owing to recent advances in microsurgical techniques.[1,2] Higher patient satisfaction and quality of life scores on the BREAST-Q have been reported after autologous tissue reconstruction than after artificial breast reconstruction.[3–6]

There are several options for the free flap used in autologous tissue reconstruction, including the deep inferior epigastric perforator (DIEP) flap[7,8] and the profunda artery perforator (PAP) flap.[9–11]

Regardless of the choice of free flap, after immediate breast reconstruction with autologous tissue transplantation, a skin paddle area of grafted tissue will be exposed on the body surface as a patch instead of the skin removed during mastectomy, and this skin paddle area is likely to become the nipple area in the future. This skin paddle is a factor that significantly compromises the appearance of the reconstructed breast after subsequent reconstruction of the nipple–areola complex (NAC).[12]

Skin-sparing mastectomy (SSM), on the other hand, minimizes exposure of the skin paddle after immediate breast reconstruction by completely excising the mammary tissue, including the NAC, previous biopsy incisions, and the skin overlying a superficial tumor, while preserving as much of the skin on the breast surface as possible.[13,14] Preserving the breast anatomy to the maximum extent possible, including the natural skin envelope and inframammary fold (IMF) of the breast, gives the reconstructed breast a high degree of cosmetic acceptability and symmetry.[15] We have actively adopted the minimal scar autologous breast reconstruction technique, in which the exposed skin paddle after breast reconstruction using SSM is used for delayed nipple reconstruction with local skin valves, at the same time completely removing the remaining skin islands.[16] However, the position and size of the skin paddle, which is placed symmetrically during surgery, change over time, making it difficult to create a

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Table 1. Patient Demographic, Clinical, and Surgical Data

Variable	Summary Statistic (Range or %)
Patients, N	35
Mean age, y	46 (32–73)
Mean body mass index*	20.4 (15.3–32.5)
Mean mastectomy specimen weight, g	271 (75–1282)
Mean transplanted flap weight, g	341 (158–918)
ASA Score	
I	16 (46%)
II	19 (54%)
Smoking history	9 (25%)
Hypertension	0 (0%)
Previous adjuvant treatment	
Chemotherapy	3 (9%)
Radiotherapy	0 (0%)
Lymphadenectomy	
None	0 (0%)
SLNB	31 (89%)
ALND	4 (11%)

*Calculated as kg/m².
ALND, axillary lymph node dissection; ASA, American Society of Anesthesiologists physical status; SLNB, sentinel lymph node biopsy.

symmetrically positioned nipple using this technique in some cases. Similarly, the morphology of the breast after autologous tissue reconstruction is thought to change over time,[17] and it is important to be able to predict the amount of this change before surgery to reproduce a breast with acceptable symmetry. In this study, we retrospectively examined the changes in position and morphology of the skin paddle of the reconstructed breast over time.

PATIENTS AND METHODS

Thirty-five women who underwent SSM and immediate autologous breast reconstruction (IABR) with a DIEP flap (n = 19) or PAP flap (n = 16) at Tokyo Women's Medical University Yachiyo Medical Center or Tokyo Women's Medical University Hospital between 2018 and 2023 were retrospectively reviewed. Cases included in this study were (1) those in which NAC preservation was determined to be infeasible by the breast surgeon preoperatively, and (2) those in which rapid pathology of the NAC backside tissue was performed intraoperatively and nipple-sparing mastectomy was determined to be infeasible, resulting in SSM. The study was approved by the ethics committee of Tokyo Women's Medical University (approval no.: 2020-0088). All patients provided written informed consent to their data being included in the study. All mastectomy procedures were performed by any of four breast surgeons during the study period. Patients had a mean age of 46 (range, 32–72), mean body mass index of 20.4 (range, 15.3–32.5), mean mastectomy specimen weight of 271(range, 75–1282) g, and mean transplanted flap weight of 341 (range, 158–918) g (Table 1). The following exclusion criteria were applied: (1) recurrence of breast cancer, (2) bilateral breast cancer, (3) partial mastectomy, (4) skin fragility and/or central obesity due to long-term steroid use, (5)

Takeaways

Question: Does the position and morphology of the skin paddle of the reconstructed breast change over time?

Findings: The position of the skin paddle after autologous breast reconstruction shifts toward the outer caudal side, and the size of the skin paddle tends to become larger.

Meaning: When planning delayed nipple reconstruction with a local flap designed on a skin paddle, the skin paddle should be positioned slightly more mediocranially than the healthy nipple, and its width should be narrower.

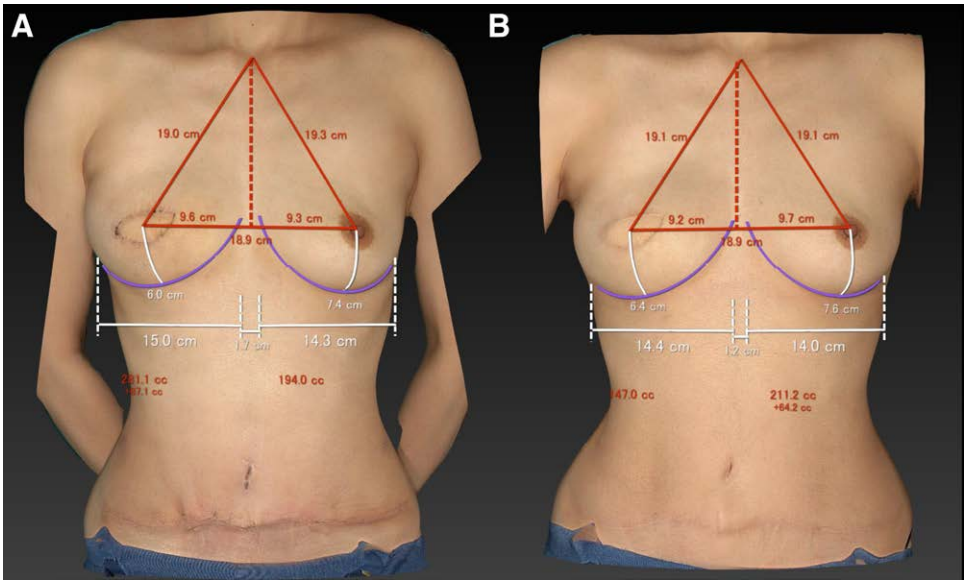

Fig. 1. Three-dimensional imaging data for the reconstructed breasts obtained by the Vectra H2 system. A, Data recorded 1 month after breast reconstruction. B, Data recorded 12 months after breast reconstruction.

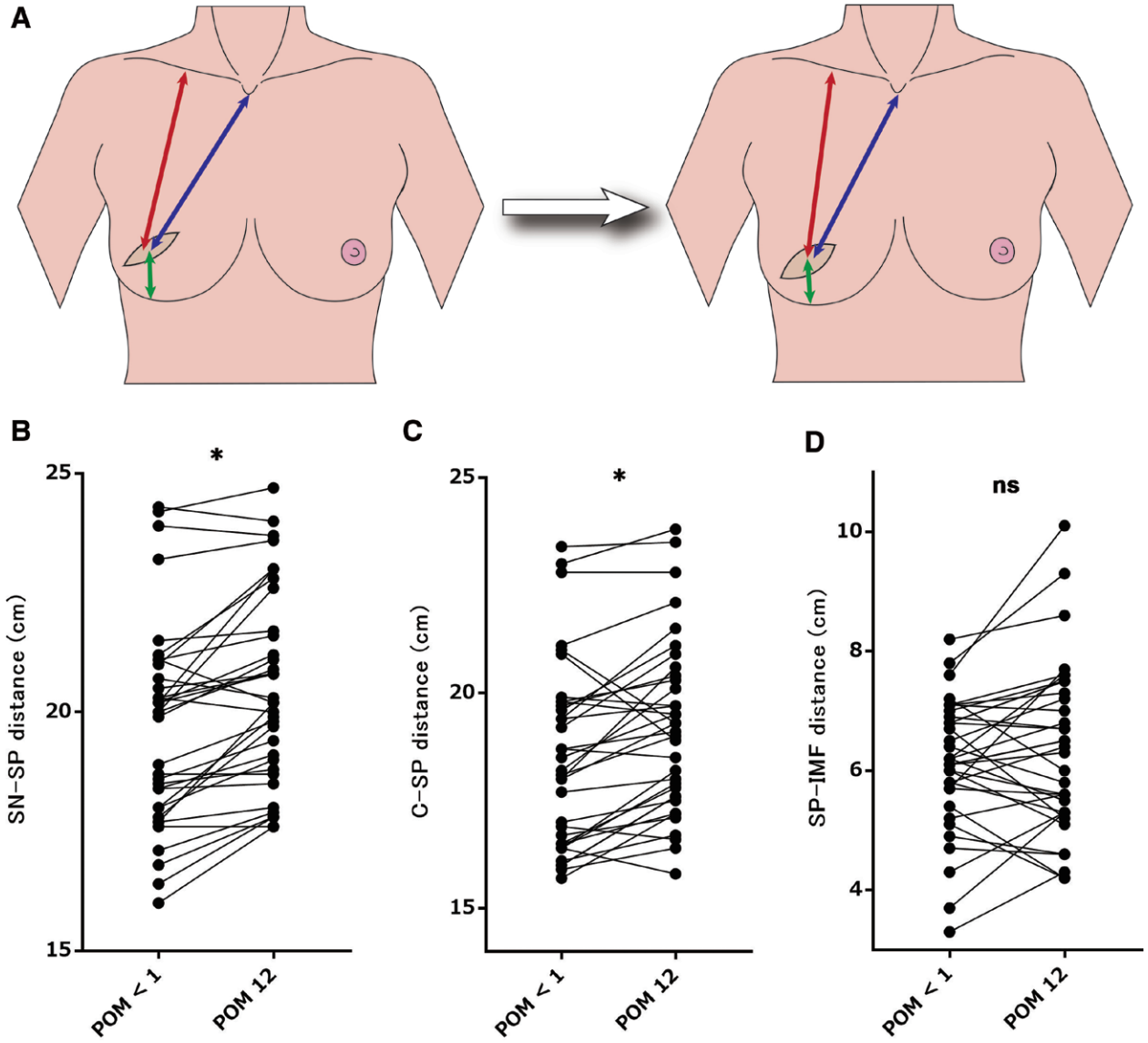

Fig. 2. SN-SP, C-SP, and SP-IMF distances at 1 month and 12 months after surgery. A, Schema showing changes in these distances over time. Blue arrow, SN-SP distance; red arrow, C-SP distance; green arrow, SP-IMF distance. B, Graph comparing SN-SP distance at 1 month and 12 months after surgery. C, Graph comparing C-SP distance at 1 month and 12 months. D, Graph comparing SP-IMF distance at 1 month and 12 months. *$P < 0.05$, paired *t* test; ns, not statistically significant; POM, postoperative month.

inflammatory breast cancer, (6) locally advanced breast cancer, (7) advanced mastoptosis, (8) congenital breast anomalies, and (9) pre- and postoperative radiotherapy.

Surgical Technique

SSM was performed using a spindle-shaped design with equal top and bottom curves of the smallest possible size, including the NAC. Because our institution uses the internal thoracic artery and vein as the recipient vessels for the free flap, the breast surgeons use a spindle-shaped incision with a wider inward incision than a racket-shaped incision for the SSM design. Sentinel lymph node biopsy was the first choice to reach the sentinel node site continuously through the breast skin incision. If the size of the breast or the flexibility of the skin made this difficult, a skin incision was made directly above the sentinel node, and the node was removed. Even when axillary dissection was necessary because of sentinel node metastasis, the surgical field was sufficient for axillary dissection after total mastectomy. When selecting the free flap, we used the preoperative mammary gland weight prediction method with the Vectra H2 system (Canfield Scientific, Parsippany, N.J.)[18] and the PAP flap weight prediction method using computed tomography of the lower extremity, which we have reported in the past,[19] and selected the vertical PAP (v-PAP) flap for patients whose predicted mammary gland tissue volume was smaller than the predicted PAP flap volume. The v-PAP flap was selected in cases where the predicted mammary tissue volume was smaller than that of the predicted PAP flap volume, and the DIEP flap was selected in cases where

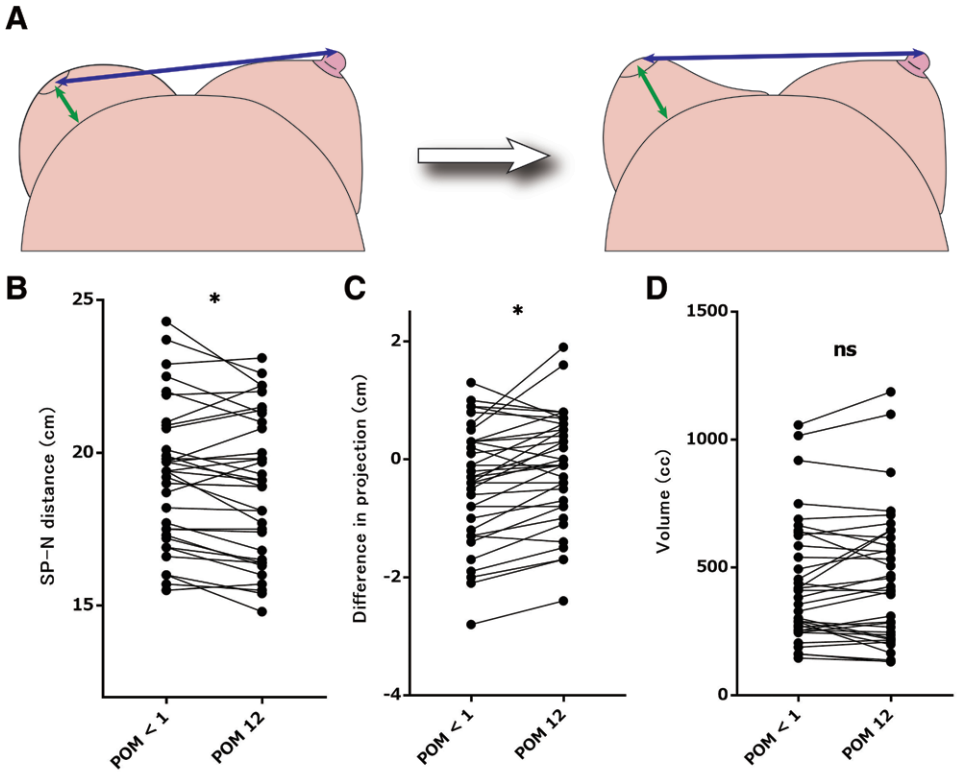

Fig. 3. SP-N distance and differences in projection and volume at 1 month and 12 months after surgery. A, Schema showing changes in these parameters over time. Blue arrow, SP-N distance; green arrow, projection. B, Graph comparing SP-N distance at 1 month and 12 months. C, Graph comparing the difference in projection at 1 month and 12 months. D, Graph comparing the difference in volume at 1 month and 12 months. *$P < 0.05$, paired t test; ns, not statistically significant; POM, postoperative month.

the v-PAP flap was predicted to be inadequate. The v-PAP and DIEP flaps were raised using the standard technique, and the flap weight was trimmed to approximate the weight of the mastectomy specimen, taking the angiosome into consideration. The skin paddle was then coned by suturing it in the appropriate direction using absorbable thread, which was placed in a subcutaneous pocket, and the skin paddle was positioned with the patient sitting upright while we checked the breast morphology and marked it. After the skin paddle was removed from the pocket, the epidermal component excluding the skin paddle exposed from the breast was removed. Finally, after creation of a vascular anastomosis between the vascular pedicle of the flap and the recipient vessel under a microscope, the skin valve was returned to the thoracic subcutaneous pocket, and the skin around the skin island was closed using sutures. The medial thigh or abdominal donor area was closed with primary sutures in all cases. NAC reconstruction was performed at the patient's request 12 months after breast reconstruction.

Three-dimensional Evaluation of Changes in Skin Paddle Morphology

The position and morphology of the skin paddle at 1 month after immediate reconstruction surgery was compared with that at 12 months postoperatively using the Vectra H2 system. Briefly, after taking three stereo images with a three-dimensional (3D) camera, 3D images were constructed, and the specific distance between the two breasts was automatically measured using the Vectra BreastSculptor system (Canfield Scientific) on a PC. The intersection of the long and short axes of a skin island was defined as the center of the skin paddle. The distance between the sternal notch and the skin paddle center (SN-SP), the distance between the midpoint of the clavicle and the skin paddle center (C-SP), the distance between the skin paddle center and the inframammary fold (SP-IMF), the distance between the skin paddle center and the contralateral nipple (SP-N), and the difference in projection were measured on the constructed 3D images. The size (area and long and short axis length) of the skin paddle used for reconstruction of the breast was also measured (Fig. 1).

Statistical Analysis

All parameters measured at 1 and 12 months after surgery are presented as the mean ± SD or as the percentage and were compared between the two time points using the paired t test. All statistical analyses were performed using Prism (version 7.02) for Windows (GraphPad Software, La Jolla, Calif.). A P value of less than 0.05 was considered statistically significant.

RESULTS

There was a significant difference between the mean C-SP distance measured at 1 month and that measured

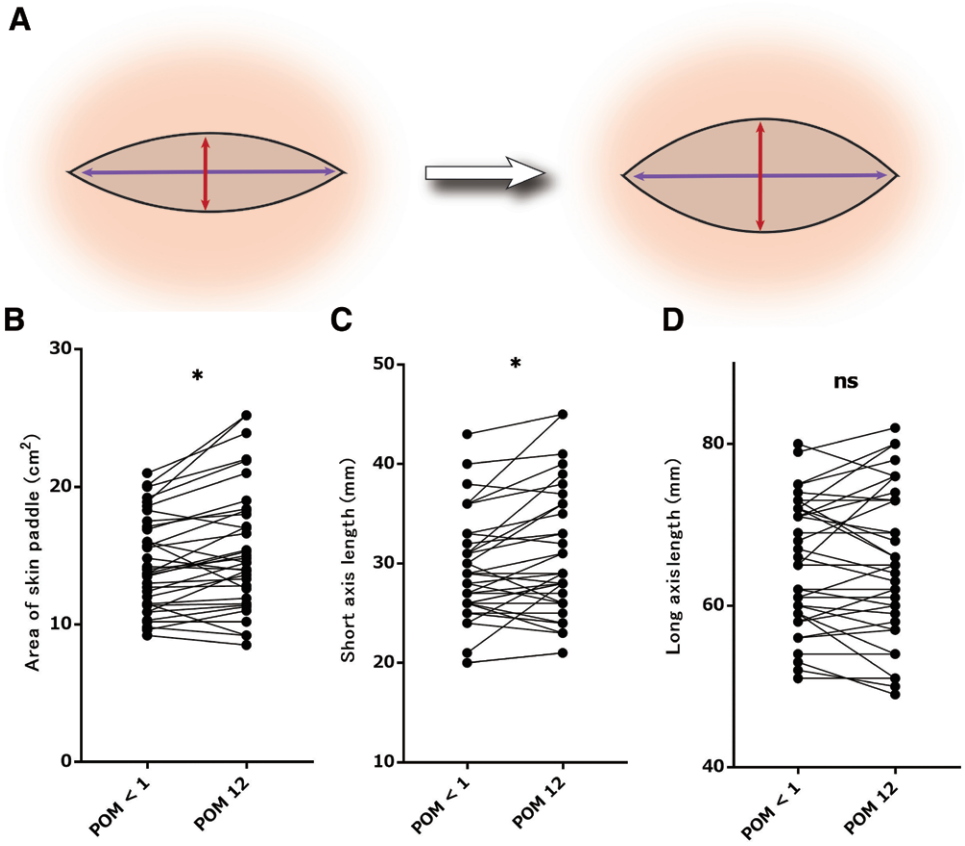

Fig. 4. Size of the skin paddle at 1 month and 12 months after surgery. A, Schema showing changes over time. Red arrow, short axis length; purple arrow, long axis length. B, Graph comparing the skin paddle area at 1 month and 12 months. C, Graph comparing the short axis length at 1 month and 12 months. D, Graph comparing the long axis length at 1 month and 12 months. *$P < 0.05$, paired *t* test. ns, not statistically significant; POM, postoperative month.

at 12 months postoperatively [18.5 ± 2.137 cm versus 19.18 ± 2.018 cm; t(35) = 4.051, $P = 0.0003$; Fig. 2A, B]. The increase in mean C-SP distance was 3.9%. There was also a significant difference in mean SN-SP distance between 1 month and 12 months after surgery [19.67 ± 2.135 cm versus 20.47 ± 2.013 cm; t(35) = 5.345, $P < 0.0001$; Fig. 2C], representing an increase to 104.3%. There was no significant difference in mean SP-IMF distance between 1 and 12 months postoperatively [6.129 ± 1.089 cm versus 6.371 ± 1.413 cm; t(35) = 1.568, $P = 0.1261$; Fig. 2D].

There was a significant increase in projection between 1 month and 12 months postoperatively [-0.4029 ± 0.9916 cm versus -0.1257 ± 0.9479 cm; t(35) = 3.773, $P = 0.0006$; Fig. 3A, B]. There was a significant difference in mean SP-N distance between 1 and 12 months [19.2 ± 2.288 cm versus 18.86 ± 2.356 cm; t(35) = 2.58, $P = 0.0144$; Fig. 3C], indicating a decrease of 1.76%. There was no significant difference between mean volume at 1 month and 12 months postoperatively [440.6 ± 240.7 cm^3 versus 450.4 ± 262.8 cm^3; t(35) = 0.7412, $P = 0.4636$; Fig. 3D], indicating a volume change of 101.1%.

There was a significant difference in mean skin paddle area between 1 month and 12 months after surgery [14.39 ± 3.38 cm^2 versus 15.47 ± 4.496 cm^2; t(35) = 3.287, $P = 0.0024$; Fig. 4AB]. There was also a significant difference in the mean short axis length of the skin paddle between 1 and 12 months postoperatively [29.09 ± 5.376 mm versus 30.54 ± 6.528 mm; t(35) = 2.852, $P = 0.0073$; Fig. 4C]. There was no significant difference in the mean length of the long axis between 1 and 12 months [65.14 ± 8.001 mm versus 65.17 ± 9.398 mm; t(35) = 0.04054, $P = 0.9679$; Fig. 4D]. The changes in skin paddle area and long and short axis length were 106.8%, 99.95%, and 101.3%, respectively.

Clinical Case

A representative case was a 42-year-old woman with cancer of the right breast who underwent SSM with sentinel lymph node biopsy. The amount of skin resected (including the NAC) was 7 × 4 cm, and the mastectomy specimen weighed 543 g (Fig. 5A). A v-PAP flap (20 × 14 cm), with a PAP arising from the right deep femoral artery as a vascular pedicle, was harvested from the right thigh, and IABR was performed (Fig. 5B).

The skin paddle position had measurements of C-SP 18.0, SN-SP 20.2, SP-IMF 6.9, N-N 20.8, and projection -0.2 at 1 month postoperatively, and C-SP 20.8, SN-SP 23, SP-IMF 6.7, SP-N 21.4, and projection -0.1 at 12 months postoperatively. The skin paddle area was 13.7 cm^2, the

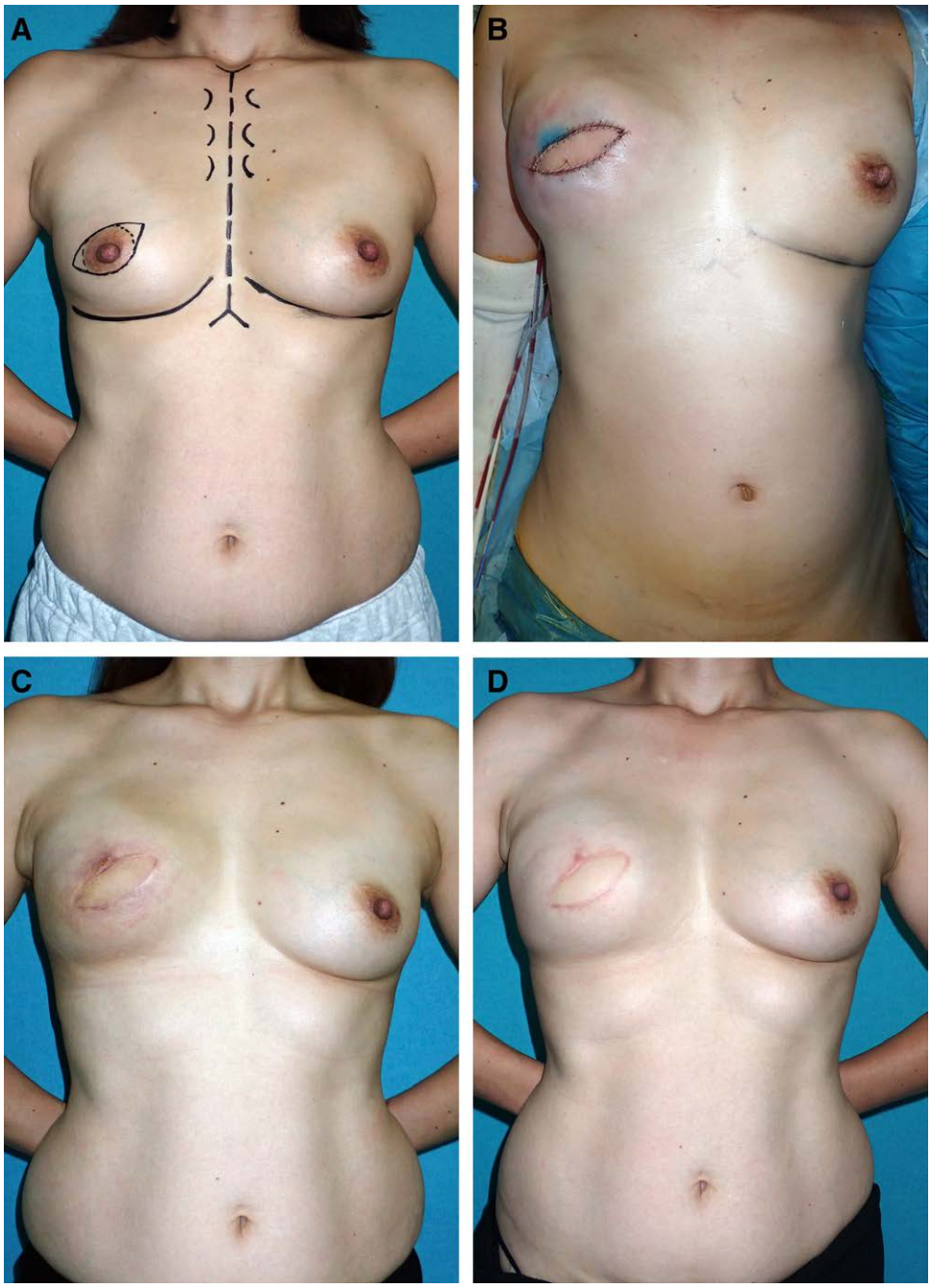

Fig. 5. Representative case of a 42-year-old woman (patient 2) who underwent SSM and sentinel lymph node biopsy for cancer of the right breast. A, Preoperative findings. B, SSM and sentinel lymph node biopsy were performed, and IABR was performed using a vertical PAP flap. C, Appearance at 1 month after breast reconstruction. D, Appearance at 12 months after breast reconstruction.

long axis was 71 mm, and the short axis was 26 mm at 1 month postoperatively and 17.1 cm^2, 76 mm, and 28 mm, respectively, at 12 months, representing respective increases of 124%, 107%, and 107% (Fig. 5C, D).

DISCUSSION

The results of this study suggest that the skin paddle position after IABR is shifted slightly toward the outer caudal side. In the normal breast, the nipple position is reported to move caudally as the skin on the cephalic side of the nipple stretches with age.[20] Previous studies have shown that the elasticity of the skin decreases most above and inside the breast with age.[21] Furthermore, after menopause, hormones cause an increase in breast fat and volume, resulting in changes in breast morphology.[20] Therefore, in reconstruction cases, such as the representative case described above, it is probable that after

transplantation the tissue moves to the lateral caudal side, which is the opposite of the area with low skin tension, during the process of acclimation over time. The condition of the reconstructed breast can be considered to be the same as that of the postmenopausal breast, given that surgical removal of the reconstructed breast results in loss of supporting tissues, such as the Cooper ligament, and replacement of the mammary tissue with fat. This would result in changes similar to those seen during normal aging but over a short period of time. We speculate that the shorter distance between the skin paddle and the contralateral nipple is the result of higher projection, which shortens the 3D distance. Increased projection may be the result of the transplanted tissue descending caudally and increasing the volume ratio of the lower pole. When planning delayed nipple reconstruction with a local flap designed on a skin paddle, the paddle should be positioned slightly more mediocranially than the healthy nipple. However, this study included only cases in which SSM type 1 (small spindle-shaped excision design including the NAC) was performed. Therefore, the window to insert the skin paddle into the subcutaneous pocket was very small, making it difficult to secure the skin paddle in the pocket. We believe that if the skin paddle could be sufficiently secured in the pocket, the physiological changes in morphology might be a little less pronounced.

In this study, we found that the skin paddle tended to increase in size after autologous tissue reconstruction. The probable reasons for this increase are as follows: (1) a decrease in the tension generated around the outer circumference of the skin paddle because of maturation of the postoperative scar, (2) an increase in tension in the short axis of the skin paddle in response to drooping of the reconstructed breast caused by gravity, and (3) an increase in the surface area of the reconstructed breast owing to an increase in the volume of transplanted tissue. We recommend that patients be informed preoperatively of the possibility of an increase in the size of the skin paddle, which is exposed in a patchy fashion. Considering the results of this study, NAC reconstruction for SSM cases may require a waiting period of about 1 year.

This study has some limitations. First, only mastectomy cases with SSM were included, and non-SSM with extensive skin excision added may have resulted in different changes. In SSM cases, ulceration of the mastectomy resection margin can occur, but we did not consider this with respect to delayed healing in this study. Second, the size of the reconstructed breast was not considered. Third, differences in the type of transplanted skin paddle, changes in the volume of the reconstructed breast due to postoperative weight changes, and individual differences in skin tensile strength due to age, menopause, or other factors were not taken into consideration. In addition, postoperative chemotherapy and/or estrogen blockers may cause weight gain or loss, but changes in weight and body mass index were not examined in this study. A longer follow-up will be needed in the future, as morphological changes in the reconstructed breast may continue to occur beyond 12 months postoperatively. Therefore, further research is needed to obtain more definitive evidence of morphological changes in the skin paddle over time.

CONCLUSIONS

In this study, we found that (1) the position of the skin paddle was shifted toward the outer caudal side after IABR, and (2) the skin paddle tended to increase in size. When planning delayed nipple reconstruction with a local flap designed on a skin paddle, the paddle should be positioned slightly more mediocranially than the healthy nipple, and its width should be narrower.

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DISCLOSURE

The authors have no financial interest to declare in relation to the content of this article.

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