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Rhomboid Flap Reconstruction after Mastectomy for Locally Advanced Breast Cancer

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Background: In patients undergoing mastectomy for locally advanced breast cancer (LABC), surgical skin flap reconstruction is sometimes required in order to cover large skin defects. This study assessed the efficacy of local, cutaneous (rhomboid) flap reconstruction after mastectomy by comparing data from patients with LABC requiring local flap reconstruction after mastectomy and those that underwent mastectomy alone.

Methods: Data from 68 patients with LABC who underwent mastectomy were reviewed retrospectively; 14 underwent local (rhomboid) flap reconstruction after mastectomy (local flap group) and 54 underwent direct closure after mastectomy (direct closure group). A pinch test was performed to determine the closure method. Data on the operation, postoperative complications, and postoperative quality of life (QOL) were compared between groups.

Results: It was possible to close defects in the local flap group that were significantly larger than those in the direct closure group (p=0.0002). There was no significant difference in postoperative complications between groups. Although operative duration was significantly longer in the local flap group than in the direct closure group (p=0.016), the average difference was only 25 minutes. There was no significant difference in variables related to postoperative QOL.

Conclusions: Rhomboid flap reconstruction was effective for covering large defects after mastectomy in patients with LABC. (J Nippon Med Sch 2021; 88: 63–70)

Key words: locally advanced breast cancer, breast reconstruction, local flap, postoperative complication

Introduction

The standard therapy for locally advanced breast cancer (LABC) is multidisciplinary therapy, and the most common treatment combination is neoadjuvant systemic therapy (NST) followed by local therapy such as surgery and radiotherapy. The response rate to NST has been increasing for patients with LABC. If NST is effective and signs of tumor invasion, such as ulcers, scars, and red spots, on breast skin are limited, the area of skin resection is small enough that conventional mastectomy can be performed without reconstruction. However, if signs of tumor invasion persist despite NST, resection of a large skin area and reconstruction become necessary.

Skin grafts and several types of myocutaneous flaps have been used for reconstruction in such cases. In an earlier report, we discussed the merits of local, cutaneous (rhomboid) flap reconstruction for large skin defects and our favorable findings regarding postoperative complications and wound healing[1]. However, no published study has compared mastectomy requiring local flap reconstruction with mastectomy alone in patients with LABC. Therefore, to evaluate the efficacy of local (rhomboid) flap reconstruction after mastectomy in patients with LABC, this study compared data on the procedure and postoperative complications between patients requiring local flap reconstruction after mastectomy and those that

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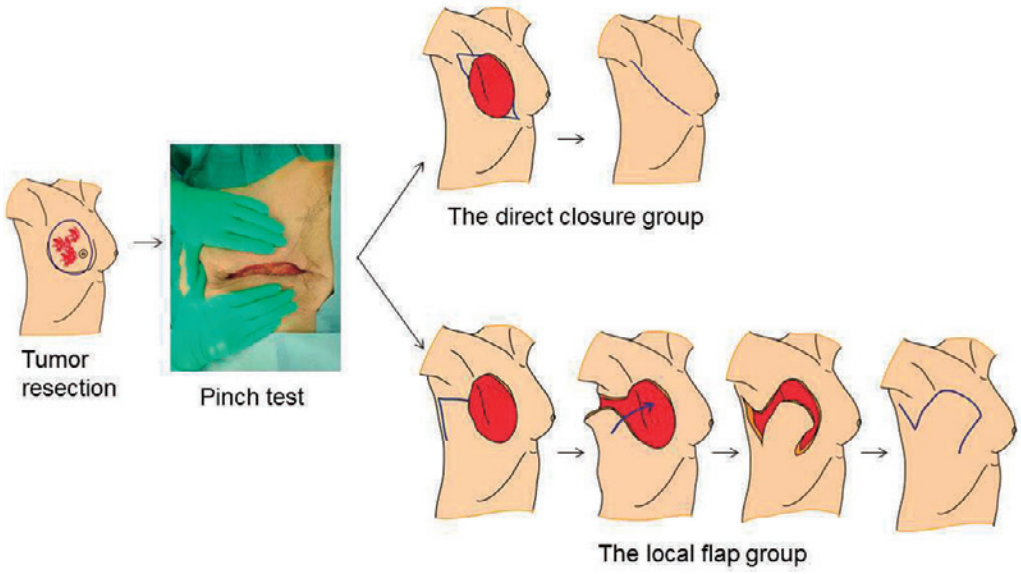

Fig. 1 Selection of closure method
A round skin resection line, including the area of tumor invasion and nipple-areolar complex, is drawn. After tumor resection, the pinch test is performed (left figure). If skin tension is low, the skin is trimmed to a spindle shape and closed directly (right, top figure). If skin tension is high, local flap closure is selected (right, bottom figure).

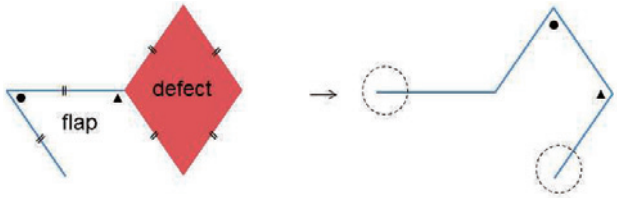

Fig. 2 Fundamental design of rhomboid flap
A flap with sides equal in length to those of the rhomboid shape of the defect is designed (left figure). The flap is moved and transposed with the edges marked with a circle and a triangle, which are matched to the edges of the rhomboid shape of the defect (right figure). Dog-ear deformities appear at the flap base and axillary area (right figure, circle)

underwent mastectomy alone.

Materials and Methods

We retrospectively reviewed the records of patients who had received a diagnosis of LABC (primary breast cancer diagnosis of clinical stage T4, any N, M0, in accordance with the eighth edition of the Union for International Cancer Control [UICC] tumor-node-metastasis [TNM] classification of malignant tumors[2]) and had undergone mastectomy at Saitama Cancer Center during the period from August 2011 through September 2016. All breast cancer surgeries and reconstructions were performed or supervised by the first author. The study was approved by the Ethics Committee Board of the Saitama Cancer Center.

The patients were divided into 2 groups in accordance with the skin defect closure method used after mastectomy, ie, the local flap group and direct closure group for local flap reconstruction and direct closure, respectively. The selection of closure methods is shown in **Figure 1**. A round skin resection line including signs of tumor invasion, such as ulcers, scars, or red spots, on the breast skin and nipple-areolar complex is drawn. After tumor resection, a pinch test[3] is performed to assess skin tension (**Fig. 1**, left figure). If the pinch test indicates low skin tension and the skin defect appears suitable for direct closure, the skin is trimmed to a spindle shape and closed directly after tumor resection (**Fig. 1**, right, top figure). If skin tension is high and direct closure is not indicated, local flap closure is selected (**Fig. 1**, right, bottom figure).

Rhomboid flap reconstruction was performed using our previously described technique[1]. The fundamental design of the rhomboid flap is shown in **Figure 2**. The skin defect is considered rhomboid in shape, and a flap with sides equal in length to those of the rhomboid shape of the defect is designed (**Fig. 2**, left figure). The flap is moved and transposed with the edges marked with a circle and a triangle, which are matched to the edges of the rhomboid shape of the defect (**Fig. 2**, right figure). In principle, the flaps were designed in accordance with the above description; however, the flap for

each patient was modified depending on the shape and size of the skin defect and the degree of skin softness. The area of the actual skin defect is sometimes slightly larger than the skin resection area marked before tumor resection, because skin contracture caused by the tumor is released after tumor resection. Therefore, the local flap is designed to be slightly larger than the local flap area estimated from the marked skin resection area before tumor resection. Dog-ear deformities appear at the base of the flap after the flap and axillary area are moved to the defect (**Fig. 2**, right figure circle). Although dog-ear deformities can be repaired[4,5], such deformities at the base of the flap should be repaired in a secondary surgery, that is, after complete healing of the flap. Repair of the dog-ear deformity during initial surgery (resection of LABC and rhomboid flap reconstruction) would encroach on the flap base and endanger blood circulation of the flap[5]. A dog-ear deformity at the axillary area can be repaired during the initial surgery as it will not compromise blood circulation of the flap.

Patient characteristics collected included age, body mass index (BMI), body surface area (BSA; Du Bois formula: $\text{weight}^{0.425} \times \text{height}^{0.725} \times 0.007184$), smoking status, diabetes status, administration of corticosteroids, clinical stage according to the eighth edition of the UICC TNM classification, NST data including NST rate and pathological response according to the Japanese Breast Cancer Society (JBCS) classification[6], adjuvant therapy data including type of therapy and delay of adjuvant therapy due to surgical complications with systemic therapy started more than 12 weeks after surgery[7] or radiotherapy started more than 8 weeks after surgery[8,9], and operation data including skin resection area, duration of operation, amount of blood loss, type of axillary operation, and length of hospital stay after operation. The skin resection area was calculated using the formula for the area of an ellipse, namely, (major axis × 1/2) × (minor axis × 1/2) × π. Ratios of the skin resection area to BMI and BSA were also calculated. Data on postoperative complications, including wound dehiscence (requiring resuture), hematoma (requiring reoperation), infection (requiring antibiotics and surgical debridement or irrigation), and skin necrosis (requiring surgical debridement), were collected, as were data on factors influencing postoperative quality of life (QOL), including limitation of shoulder joint movement (requiring physical therapy), lymphedema (requiring compression bandage), and revision surgery (to correct the cosmetic deformity).

The Fisher's exact test, Student's t-test, and Mann-Whitney's U test were used to compare patient and tumor characteristics, clinical stage, NST data, adjuvant therapy data, operation data, and postoperative complications. A P value of <0.05 was considered statistically significant. All statistical analyses were performed with EZR (Saitama Medical Center, Jichi Medical University, Saitama, Japan), a graphical user interface for R (The R Foundation for Statistical Computing, Vienna, Austria) that is a modified version of R Commander and adds statistical functions frequently used in biostatistics[10].

Results

Of the 68 patients who underwent mastectomy for LABC, 14 were in the local flap group and 54 were in the direct closure group. The patient and tumor characteristics are summarized in **Table 1**. The rate of human epidermal growth factor 2 (HER2)-positive tumor was significantly lower in the local flap group than in the direct closure group (0% vs 33.3%; $P = 0.014$). There was no significant difference in age, BMI, BSA, smoking status, diabetes status, administration of corticosteroids, clinical stage, or estrogen receptor (ER) status between groups.

Table 2 shows NST and adjuvant therapy data. There was no significant difference in NST rate or pathological response to NST, type of adjuvant therapy, or delay of adjuvant therapy between groups. A 53-year-old woman in the direct closure group could not start postoperative radiotherapy until 11 weeks after surgery, because of wound infection and skin dehiscence requiring irrigation, surgical debridement, and re-suture. Although she had no complications, she was a current smoker. Her BMI was 18.5, BSA was 1.78 m^2 and skin resection area was 33 cm^2.

Table 3 shows data on the operation, postoperative complications, and postoperative QOL. The skin resection area was significantly larger in the local flap group than in the direct closure group (112.7±71.4 cm^2 vs 45.4±26.8 cm^2 P=0.0002). Ratios of skin resection area to BMI and BSA were also higher in the local flap group than in the direct closure group (5.1±3.6 vs 2.0±1.3, p=0.0001, and 77.8±51.3 vs 30.2±17.2, p=0.00003). However, the skin resection area and the ratios of skin resection area to BMI and BSA varied widely in both groups. Operation duration was significantly longer in the local flap group than in the direct closure group (142.5±40 minutes vs 117 ±22.6 minutes; P=0.016). There was no significant difference in the amount of blood loss, type of axillary operation, length of hospital stay, incidence of postoperative complications, or factors affecting QOL. There were 2

Table 1 Patient and tumor characteristics

	Local flap group n=14 (%)	Direct closure group n=54 (%)	*P*
Mean age ± SD (years)	63.5 ± 13.1	57.2 ± 11.3	0.07
BMI ± SD	22.9 ± 2.9	23.6 ± 4.6	0.58
BSA ± SD (m^2)	1.46 ± 0.14	1.52 ± 0.13	0.31
Smoking	3 (21.4)	15 (27.8)	0.75
Diabetes mellitus	1 (7.1)	7 (13)	1
Administration of corticosteroids	0	1 (1.9)	1
Clinical stage			
T4a	0	0	
T4b	11 (78.6)	46 (85.2)	0.68
T4c	2 (14.3)	3 (5.6)	0.27
T4d	1 (7.1)	5 (9.3)	1
N0	2 (14.3)	8 (14.8)	1
N1	7 (50)	25 (46.3)	1
N2	2 (14.3)	11 (20.4)	1
N3	3 (21.4)	10 (18.5)	1
Estrogen receptor–positive	10 (71.4)	34 (63)	0.76
HER2–positive	0	18 (33.3)	0.014

Table 2 Neoadjuvant and adjuvant therapy data

	Local flap group n=14 (%)	Direct closure group n=54 (%)	*P*
Preoperative systemic therapy	12 (85.7)	46 (85.2)	1
Pathological response			
Grade 0	0	0	
1	8 (66.7)	31 (67.4)	1
2	2 (16.7)	10 (21.7)	1
3	2 (16.7)	5 (10.9)	0.62
Adjuvant therapy	14 (100)	52 (96.3)	1
Systemic therapy	12 (85.7)	42 (80.8)	1
Irradiation	9 (64.3)	31 (60)	1
Delay of adjuvant therapy	0	1 (1.9)	1

cases of skin necrosis in the local flap group. These were treated quickly and did not delay adjuvant therapy. There was no revision surgery, including repair of dog-ear deformities, in either group.

Clinical Case

A 69-year-old woman presented with a right breast tumor with skin ulcer and redness of the surrounding skin. The diagnosis was right ER-positive, HER2-negative LABC (cT4bN1M0 clinical stage IIIB according to the eighth edition of the UICC TNM classification). The patient underwent NST (doxorubicin, cyclophosphamide, and docetaxel). After NST, the tumor showed partial response. Surgery was scheduled for 4 weeks after completion of systemic therapy.

Mastectomy with 12 × 8 cm (75.4 cm^2) skin resection (including the ulcer and red spot on the skin) and axillary lymph node dissection were performed (**Fig. 3A**). After tumor resection, the size of the skin defect was larger because of the release of the skin contracture (**Fig. 3B**). A pinch test revealed that skin tension was high and that the defect could not be closed directly; therefore, it was closed by local flap closure. A rhomboid flap with 8-cm limbs was dissected and used to cover the skin defect (**Fig. 3C**). The total duration of the operation was 171 minutes, and the amount of blood loss was 114 mL. There were no postoperative wound complications. The patient was discharged from hospital on postoperative day 7. Pathological examination revealed ypT4bN1a (according to the eighth edition of the UICC TNM classifica-

Table 3 Operation and postoperative complications and QOL data

	Local flap group n=14 (%)	Direct closure group n=54 (%)	*P*
Skin resection area ± SD (cm^2)	112.7 ± 71.4	45.4 ± 26.8	0.0002
Skin resection area / BMI	5.1 ± 3.6	2.0 ± 1.3	0.0001
Skin resection area / BSA	77.8 ± 51.3	30.2 ± 17.2	0.00003
Duration of operation ± SD (min)	142.5 ± 40	117.7 ± 22.6	0.016
Blood loss ± SD (mL)	124.4 ± 63.1	184.3 ± 172.1	0.57
Axillary operation			
Sentinel lymph node biopsy	2 (14.3)	7 (13)	
Axillary lymph node dissection	12 (85.7)	47 (87)	1
Hospital stay ± SD (day)	7.6 ± 2.2	7.1 ± 3.1	0.18
Wound dehiscence	0	4 (7.4)	0.57
Hematoma	0	2 (3.7)	1
Infection	0	4 (7.4)	0.57
Skin necrosis	2 (14.3)	3 (5.6)	0.27
Limitation of shoulder joint movement	1 (7.1)	3 (5.6)	1
Lymphedema	1 (7.1)	2 (3.7)	0.505
Revision surgery	0	0	

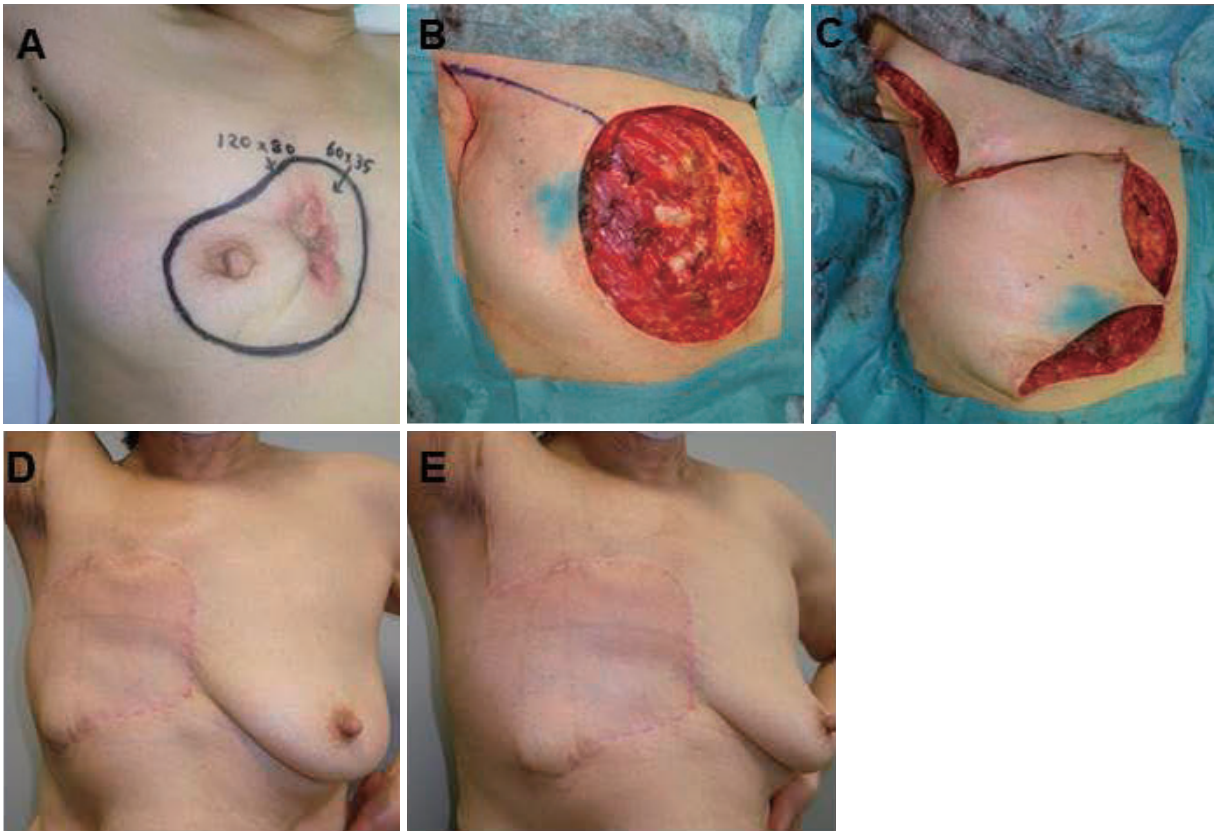

Fig. 3 Clinical case

The skin resection line was designed to include the skin ulcer and a red spot (A). After tumor resection, the skin defect was larger (B). Rhomboid flap reconstruction was performed (C). There was no limitation in shoulder joint movement after surgery (D, E).

tion) invasive ductal carcinoma with a grade 1a pathological response (according to the JBCS classification). The patient underwent postoperative irradiation of the chest wall and supraclavicular lymph node and hormonal therapy (aromatase inhibitor). At 24 months after surgery, there was no local or distant metastasis, no limita-

tion in shoulder joint movement (**Fig. 3D, 3E**), and no lymphedema. The patient was satisfied with the result of the operation and declined revision surgery.

Discussion

Patients with LABC who undergo combined systemic and local therapy have better outcomes than those who undergo systemic therapy or local therapy alone[11]. Thus, the current standard therapy for LABC is multidisciplinary therapy combining surgery, systemic therapy, and radiotherapy. Many studies have reported no difference in overall survival between preoperative and postoperative systemic therapy[12]. However, when upfront surgery is selected for LABC, curative resection is sometimes difficult because of tumor invasion to the surrounding skin and/or chest wall or massive metastasis to regional lymph nodes. Therefore, combination NST is considered the first-choice treatment protocol for LABC followed by surgery.

Surgery and irradiation are important in the local treatment strategy for patients with LABC. In concert with irradiation, surgery improves outcomes of patients with LABC[13]. Wide local resection and reconstructive surgery are required if signs of skin invasion persist after NST. In these cases, skin grafting or various myocutaneous flaps are the usual reconstructive methods. However, these techniques have advantages and disadvantages.

Although a skin graft can cover a larger skin defect, pain is felt at the donor site, and wound control is necessary until the wound heals. Further, the skin graft site may be unsightly, especially when using the mesh skin graft method. Moreover, resection of LABC sometimes results in partial exposure of the sternum or rib, and skin grafting may be unsuitable for cortical bone[14]. Since graft survival depends on the condition of the recipient site, poor wound healing of the skin graft may delay postmastectomy irradiation and adjuvant systemic therapy, which could adversely affect overall survival[7–9].

Pedicled myocutaneous flaps, including the latissimus dorsi, external oblique, and rectus abdominis myocutaneous flaps, have also been used in reconstruction techniques[14–18]. Although these techniques can be used to cover large skin defects and even exposed bone surfaces, they have notable disadvantages, such as donor site morbidity, including muscle dysfunction, and relatively long operation times.

As an alternative method to skin grafting and myocutaneous flaps, we previously described the usefulness of rhomboid flap (local, cutaneous flap) reconstruction for skin defects after malignant breast tumor resection[1]. The rhomboid flap reconstruction method has frequently been used since Limberg described it in 1946[19], and some modified methods have been reported [20–22].

Aesthetic outcomes are better for rhomboid flap reconstruction than for skin grafting. The local flap has a similar texture and color to the surrounding normal skin, and similar skin thickness, which is not the case for a skin graft[23]. Consequently, the local flap yields better aesthetic outcomes and patient satisfaction than skin grafts[23,24]. In addition, the rhomboid flap can cover skin defects with bone exposure. LABC is associated with a high risk of local recurrence; therefore, salvage surgery for a recurrent tumor must be considered. As opposed to a skin graft, a rhomboid flap contains subcutaneous tissue and has the softness of tissue. Therefore, resection and primary closure or irradiation for a locally recurrent tumor may be possible even in the case of local recurrence within the flap. As compared with myocutaneous flap reconstruction, rhomboid flap reconstruction is less invasive. The rhomboid flap does not require any vessels or muscles in the flap. Consequently, the rhomboid flap can be implemented in a shorter operation and does not result in muscle dysfunction.

Although the rhomboid flap has advantages over skin grafts and myocutaneous flaps, it also has disadvantages. The coverable skin defect area is smaller than that for skin grafts and myocutaneous flaps. The limit of the skin defect area that can be covered with a rhomboid flap must be selected on a case-by-case basis. Skin grafts and myocutaneous flaps were not required for defects after resection for LABC during the period examined in this study. In this study, skin defects did not significantly extend over the area between the second and sixth ribs in the vertical axis and the sternal edge and midaxillary line in the horizontal axis in which the mammary gland is located[25]. We believe that a rhomboid flap can cover a defect in this area.

When considering the selection of rhomboid flap reconstruction or direct closure, the size of the skin defect may be an important factor. However, in the present study, the skin resection area varied widely in both groups. Even in patients with defects of the same size, one underwent direct closure and the other underwent rhomboid flap reconstruction. The ratios of the skin resection area to BSA and BMI also varied widely. Thus, application of rhomboid flap reconstruction should be determined on the basis of not only defect size and the patient's physical constitution, such as their BSA or BMI,

but also in relation to several other factors, such as skin softness and the volume of subcutaneous tissue. In addition, the size of the actual skin defect can sometimes increase after tumor resection, because of skin contracture after tumor release. Thus, it is difficult to evaluate application of rhomboid flap reconstruction before the operation; it is more appropriate to make this decision after tumor resection and assessment of the skin tension of the defect. Wound closure with excessive tension could disturb blood circulation at the skin edge and cause wound dehiscence or skin necrosis. A pinch test is a simple method that is correlated with actual skin tension of the defect, and utilizes a tension gauge[3]. In the present study, only one severe wound complication resulted in delayed adjuvant therapy because of high tension of the sutured skin. The test is thought to be a reasonable and reliable method to evaluate skin tension of the defect and to determine the most appropriate approach between the rhomboid flap reconstruction and direct closure.

In this retrospective study, operation data, postoperative complications, and factors in postoperative QOL were compared to evaluate the efficacy of the rhomboid flap reconstruction method after mastectomy for LABC. Using rhomboid flaps, we were able to reconstruct significantly larger skin defects in the local flap group. Although operation duration was significantly longer in the local flap group, the average difference in operation duration between the 2 groups was only 25 minutes. There was no significant difference between groups in other variables, including amount of blood loss, length of hospital stay, incidence of postoperative complications, and delay of adjuvant therapy. There were 2 cases of skin necrosis in the local flap group. These were cases of small flap tip necrosis and were quickly treated by debridement and ointment application. There was also no significant difference in factors that worsen postoperative QOL, such as limitation of shoulder joint movement and lymphedema. Cosmetic deformity that required revision surgery was not observed in either group. Therefore, the rhomboid flap method can be considered a safe reconstruction method for large skin defects after mastectomy for LABC, and local flap reconstruction after mastectomy is less invasive for patients.

Conclusion

Skin defects were significantly larger in the local flap group than in the direct closure group but could be reconstructed with rhomboid flaps. There was no significant difference in postoperative complications between the 2 groups. Although operation duration was significantly longer in the local flap group than in the direct closure group, the average difference between groups was only 25 minutes. There was no significant difference in factors affecting postoperative QOL. The pinch test appears to be useful for determining the suitability of rhomboid flap reconstruction. In sum, the rhomboid flap method is an effective reconstruction method for large defects after mastectomy for LABC.

Conflict of Interest: The authors declare no conflicts of interest.

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