INTRODUCTION

Surgical ablation of locally advanced breast cancer often results in huge defects, however immediate reconstruction of the breast mound is controversial, particularly its relationship to clinical indications and type of reconstruction. Adequately covering any large chest wall defect is the main clinical issue, and a variety of techniques have been implemented over the last four decades, including skin grafts, local skin or fasciocutaneous flaps, omens-
detail our experiences using bilateral advancement (BA), thoracoabdominal (TA), and thoracoepigastric (TE) flaps with a specific focus on outcomes, advantages, disadvantages, and proper patient selection.

**METHODS**

All mastectomies that required immediate reconstruction by a plastic surgeon at a single center between June 2008 and October 2013 were retrospectively reviewed. Breast mound reconstructions that used flaps and/or implants were excluded. Forty-three patients (45 breasts) were referred to plastic surgeons during the study period to receive chest wall reconstructions because of failed direct wound closure after mastectomy. Of these cases, 14 breasts received split-thickness skin grafts and 6 breasts received full-thickness grafts. A total of 25 local flaps were performed on 24 patients: 6 BA flaps, 9 TA flaps, and 10 TE flaps (a flap and a skin graft were performed on each breast in 1 patient) (Table 1).

Chart review was performed to obtain data on sex, age, diagnosis, oncological status, adjuvant therapy, location and size of the defects, and complications. Outcomes were compared between all three groups based on the flap type. Due to small number of patients in each group, statistical comparisons were only performed to assess the overall incidence of complications and duration before the initiation of the adjuvant therapy. Analyses were performed using SPSS software (SPSS Inc., Chicago, IL, USA).

**Table 1. Patient data**

| Patient no. | Age (yr) | Defect size (cm²) | Operation method     | Pathology       | Start of adjuvant therapy | Stage          | Mastectomy weight (g) | Complication          |
|-------------|----------|-------------------|----------------------|----------------|--------------------------|----------------|-----------------------|-----------------------|
| 1           | 44       | 20 × 15           | Bilateral advancement| Phyllodes       | Observe                  | Phyllodes     | 774.0                 | None                  |
| 2           | 40       | 12 × 12           | Bilateral advancement| IDC            | POD 28                   | T1N0M0        | 78.5                  | None                  |
| 3           | 51       | 23 × 12           | Bilateral advancement| IDC            | Observe                  | T4N1M0        | 580.0                 | None                  |
| 4           | 53       | 29 × 24           | Bilateral advancement| Phyllodes       | Observe                  | Phyllodes     | 3,916.0               | Wound dehiscence       |
| 5           | 45       | 22 × 21           | Bilateral advancement| IDC            | POD 25                   | T4N3M0        | 1,525.0               | None                  |
| 6           | 47       | 14 × 14           | Bilateral advancement| IDC            | POD 31                   | T4N1M0        | 221.0                 | None                  |
| 7           | 53       | 21 × 15           | Thoracoabdominal     | IDC            | POD 50                   | T3N0M1        | 432.0                 | Tip necrosis           |
| 8           | 36       | 15 × 11           | Thoracoabdominal     | IDC            | POD 35                   | T4N2M0        | 110.0                 | None                  |
| 9           | 44       | 26 × 26           | Thoracoabdominal     | IDC            | POD 27                   | T3N2M0        | 837.0                 | None                  |
| 10          | 34       | 22 × 17           | Thoracoabdominal     | IDC            | POD 31                   | T4N2M1        | 827.0                 | None                  |
| 11          | 40       | 21 × 20           | Thoracoabdominal     | Phyllodes       | POD 27                   | Phyllodes     | 1,184.0               | None                  |
| 12          | 41       | 21 × 19           | Thoracoabdominal     | IDC            | POD 40                   | T4N0M0        | 1,950.0               | Tip necrosis           |
| 13          | 36       | 26 × 20           | Thoracoabdominal     | IPLC           | POD 26                   | T3N0M0        | 1,095.0               | None                  |
| 14          | 41       | 18 × 17           | Thoracoabdominal     | Angiosarcoma    | POD 18                   | T3N0M0        | 587.0                 | None                  |
| 15          | 38       | 23 × 20           | Thoracoabdominal     | IDC            | POD 23                   | T3N0M0        | 1,093.0               | None                  |
| 16          | 34       | 25 × 23           | Thoracoepigastric    | IDC            | POD 37                   | T4N1M0        | 661.0                 | None                  |
| 17          | 42       | 24 × 22           | Thoracoepigastric    | IDC            | POD 36                   | T3N0M0        | 728.0                 | None                  |
| 18          | 32       | 21 × 20           | Thoracoepigastric    | IDC            | POD 21                   | T4N3M0        | 664.0                 | Tip necrosis           |
| 19          | 48       | 19 × 19           | Thoracoepigastric    | Phyllodes       | POD 38                   | Phyllodes     | 434.0                 | None                  |
| 20          | 53       | 22 × 21           | Thoracoepigastric    | IDC            | POD 38                   | T4N3M0        | 1,525.0               | Tip necrosis           |
| 21          | 46       | 14 × 14           | Thoracoepigastric    | IDC            | POD 55                   | T4N1M0        | 221.0                 | Tip necrosis           |
| 22          | 39       | 24 × 23           | Thoracoepigastric    | IDC            | POD 35                   | T4N3M0        | 1,031.0               | Tip necrosis           |
| 23          | 51       | 25 × 20           | Thoracoepigastric    | IDC            | POD 46                   | T3N0M0        | 330.0                 | None                  |
| 24          | 38       | 24 × 24           | Thoracoepigastric    | IDC            | POD 44                   | T2N3M0        | 408.0                 | Tip necrosis           |
| 25          | 45       | 19 × 18           | Thoracoepigastric    | IDC            | POD 47                   | T4N3M0        | 209.0                 | Tip necrosis           |

IDC, intraductal carcinoma; POD, postoperative day; TNM, tumor, node, metastasis; IPLC, invasive pleomorphic lobular carcinoma.
Surgical techniques

BA flap
For the BA flap, sufficient dissection begins at the margins of the mastectomy defect and progresses upward over the clavicle and downward almost to the level of the umbilicus without additional incisions. The plane of dissection is prefascial, and perforators from the epigastric and intercostal vessels are preserved whenever possible. The created cephalic and caudal flaps are sutured together, leaving a horizontal scar (Fig. 2). Trimming of “the dog ear” is usually necessary. This flap is indicated when the vertical dimensions of the flap do not exceed approximately 15 cm and its shape is approximately elliptical. If excessive tension develops during closure, a TA or TE flap should be considered.

TA flap
The TA flap is basically a rotation-advancement flap that uses the lateral intercostals, subcostal, and lumbar arteries. An incision is made at the midline of the abdomen all the way down to the umbilicus, and further dissection proceeds inferiorly and laterally across a prefascial plane. The pedicle of this flap can be identified at the medial edge of the external oblique muscle and preserved. The flap is rotated clockwise for left chest wall defects, or counterclockwise for right chest wall defects (Fig. 3). This flap is usually indicated when a higher portion of the defect lies medial, or a large amount of medial advancement is required.

TE flap
The TE flap is like a mirror image of the TA flap and uses perforators from the superior epigastric artery. The incision starts at the lower lateral angle of the defect and curves laterally down along the midaxillary line. Dissection continues medially and inferiorly, thereby preserving the superior epigastric perforators that pierce the rectus abdominis fascia (Fig. 4). This flap is usually indicated when the required medial advancement is relatively small and a higher portion of the defect lies laterally toward the axilla.

RESULTS

Between June 2008 and October of 2013, 25 local flaps were performed on 24 patients to cover chest wall defects after surgical ablation for locally advanced breast cancer. Among 24 patients, 23 were female and the mean age was 42.6 years (range, 32–53 years). Nineteen patients were diagnosed with invasive ductal carcinoma of the breast, 4 with an invasive phyllodes tumor, and 1 with a bilateral recalcitrant invasive phyllodes tumor. The mean follow-up period was 14 months (range, 4–66 years). The mean specimen weight was 1,382.5 g (range, 110–7,500 g; median, 894.5 g). The mean defect size was 400.1 cm² (range, 90–696 cm²): 321 cm² in BA flap group (n = 6) vs. 462 cm² in TA flap group (n = 9) vs. 391 cm² in TE flap group (n = 10).
The thoracoepigastric flap uses the superior epigastric vessels as perforators. The vertical scar is at the midaxillary line.

The thoracoabdominal flap uses the lateral intercostal vessels and leaves a vertical midline scar.

Total, 9 complications were recorded (36% of patients): 1 case of wound dehiscence (16.6%) in the BA flap group; 2 cases (22%) of distal flap necrosis in the TA flap group; and 6 cases (60%) of distal flap necrosis in TE flap group (P = 0.17; Fisher exact test). All complications (except in 3 patients in the TE group) spontaneously healed in less than 3 weeks with conservative wound
management (Fig. 5). Among the 6 patients with distal flap necrosis in the TE flap group, 1 patient underwent surgical debridement to promote wound healing and 2 patients eventually required skin grafts before initiating adjuvant radiation. Adjuvant chemotherapy and/or radiation were indicated for 3, 9, and 9 patients in the BA, TA, and TE groups, respectively. Adjuvant therapy commenced when sufficient wound healing was confirmed by the plastic surgeons. Adjuvant therapy was initiated after an average of 28, 30.1, or 41.4 postoperative days in BA, TA, and TE groups, respectively, and this difference was statistically significant between the TA and TE groups (P = 0.02).

**DISCUSSION**

In contrast to the dramatic evolution in the field of breast reconstruction, less attention has been paid to reconstructing large chest wall defects following a so-called “toilet mastectomy,” wherein the mastectomy is performed on locally advanced breast cancer patients with the aim of ablating the breast and skin tissues and minimizing oncologic recurrence [10,11]. A variety of locoregional tissue transfers have been introduced, and the common goal is to provide early wound healing and a low risk of total flap failure [1-5,8,9,12,13]. The BA flap is a straightforward way of closing the wound that only leaves a horizontal scar in the chest wall [4]. However, defects with greater vertical dimensions cannot be covered using this technique, and tension may result in wound dehiscence: as was the case here when the vertical dimension of the defect was 19 cm (Fig. 6).

The TA flap uses the skin, subcutaneous tissue of the anterior abdominal wall, and the direct perforating vessels of the segmental arteries that arise from the subcostal, intercostals, and lumbar arteries [2,3]. Epigastric perforators can also be preserved whenever possible. Deo et al. [2] reported that this flap is better than the myocutaneous flap in terms of mean blood loss, operating time, and length of hospital stay, and Persichetti et al. [3] have described using extended TA flaps to repair extensive defects ≤ 600 cm². We treated 2 patients (22%) with small distal flap tip necrosis, and both spontaneously healed within 3 weeks. We believe perfusion to the TA flap is relatively robust, but the main drawback of this flap is the vertical midline scar.

The TE flap is mainly supplied by perforators from the superior epigastric arteries [1,5,6]. This flap has been confused with the TA flap because of its similar nomenclature: the two terms have been called a “medially based TA flap” or “laterally based TE flap” [1,5]. The TE flap is traditionally a transversely designed transposition flap supplied by the superior epigastric artery, which was previously used to repair upper extremity defects [14]. When transversely designed, the donor site often requires skin grafts or surgery on the opposite side of the abdomen [1,5,6]. Using a midaxillary incision, the vertical scar can be concealed when the arm is in a neutral position. Our large rotation-advancement flap design has the additional advantage in that the majority of the flap can be reelevated and reused by the time scarring occurs. However, this flap is hemodynamically weak, as reported by Baroudi et al. [15], and behaves more like a random flap.

Here, 60% of the patients in the TE flap group developed distal flap necrosis. Among these, 2 patients required skin grafts because healing was delayed for more than 3 weeks due to significant necrosis. We do not know the exact reasons for this high in-
The incidence of flap-tip necrosis, although the problem could be due to the design or innate blood supply to the flap. However, considering the perforator theory, our design transfers the exact same anatomic region as the transverse or oblique design and uses the same perforator. The distal portion of this flap usually goes around the axillary area, where some redundancy in the local tissues allows relatively less closing tension (Fig. 7). So, we believe the cause of tip necrosis in the TE flap is its innate vulnerability to perfusion despite the inclusion of the superior epigastric perforators, especially when the defect extends too far laterally. We recommend debridement and skin grafting when perfusion in the distal part of the flap is suspected during the primary operation (Fig. 8).

Oncological safety is the primary concern in patients with locally advanced breast cancer, with notable advances now made in multimodality anticancer therapy, but patients who receive mastectomy followed by chest wall reconstruction using grafts or flaps may want to delay the breast reconstruction [16]. Therefore, the primary donor sites for subsequent reconstructions should be preserved whenever possible, such as the lower abdominal tissues and/or latissimus dorsi, in order to maximize the final outcomes.

In summary, the three types of local skin flap described here could be applied to locally advanced breast cancer surgeries that leave a large chest wall defect. Each flap has its own advantages and disadvantages, and selection should be based on the dimensions and location of the defect.

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