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ORIGINAL ARTICLE

Fat necrosis after breast-conserving oncoplastic surgery

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Abstract

Background Fat necrosis is a subjective early as well as delayed complication, which sometimes mimics local recurrence and ruins the quality of life by pain and poor cosmetic result. While, the frequency and severity of fat necrosis are important issues that breast surgeons should explain to the patient, these data are not revealed well.

Methods A total of 1476 patients who underwent breast surgery from January 2000 to December 2012 were enrolled in the present study. We assessed fat necrosis by mammographic and physical findings and created grading criteria: Grade (G) 0, no fat necrosis; G1, no symptomatic fat necrosis (mammographic dystrophic calcification); G2, mild symptomatic necrosis (mammographic dystrophic necrosis with tumor); G3, severe symptomatic necrosis (mammographic dystrophic necrosis with pain or skin change); and G4, symptomatic necrosis requiring surgical intervention.

Results Of the 1476 patients enrolled, 393 (27%) underwent mastectomy, and 1083 (73%) underwent breast-conserving surgery. We achieved a high rate of breast-conserving surgery at a total rate of 73% over the study period and maximum rate of 88% in 2010, using oncoplastic procedures. We mainly adopted a pedicled fat flap (417/1083; 39%) and a free dermal fat flap (40/1083; 3.7%). Among the 626 patients who underwent partial resection with no replacement for the defect, G1–G2 fat necrosis was seen in 29/626 (4.6%). While, the incidence of fat necrosis with pedicled fat flap and free dermal fat graft was 68/417 (16%) and 40/40 (100%), respectively, showing a significant difference ($p < 0.01$). Furthermore, the incidence of G3–G4 fat necrosis was significantly higher with free dermal fat grafts (25%; 10/40) than with pedicled flap (2.9%; 12/417) ($p < 0.01$). Among pedicled flaps, the incidence of fat necrosis with inframammary adipofascial flaps was 56% (14/25) which was higher than that with lateral epidermal fat flaps (12%; 33/276) ($p < 0.01$), and rotation of surrounding breast tissues (8%; 21/116) ($p < 0.01$). The incidence of G3 fat necrosis was also high at 20% (5/25) in inframammary adipofascial flaps.

Conclusions Breast-conserving oncoplastic surgery carries a risk of fat necrosis as a delayed complication. The incidence rate and severity of fat necrosis with each procedure should be assessed. We should select fat grafts with a good blood supply to replace defects of breast-conserving therapy.

Keywords Fat necrosis · Breast-conserving oncoplastic surgery · Free dermal fat flap · Pedicled fat flap

Introduction

Breast-conserving therapy (BCT), which is a combination of breast-conserving surgery (BCS) followed by whole-breast irradiation has been an established standard therapy for early-stage breast cancer since the early-1970s in Western countries. Many clinical trials, including meta-analyses, have provided clear evidence that BCT achieves long-term survival rate equivalent to mastectomy [1–4]. While, BCT was started two decades later in Japan, several pioneers in Japan started to try BCT for selected patients in the mid-1980s [5]. Since its introduction, the indications of BCT have rapidly expanded, with 50% of breast cancer patients now being treated with BCT according to the registry of the Japan Breast Cancer Society in 2015 [6].

The long-term success of BCT is measured by two end points: the rate of local control and the cosmetic appearance of the preserved breast. Therefore, many strategies, such as

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the correct diagnosis of the extent of the tumor burden [7, 8], the pathological diagnosis of the resected breast margin [9, 10], and the methods of replacing the defect of partial resection [11]. In addition, primary chemotherapy had also been adopted for breast conservation in cases of advanced breast cancer [12, 13].

To achieve good cosmetic results, various types of BCS have been reported, including the moving window technique [14], lateral tissue flap [15], and inframammary adipofascial flap [16]. We have adopted several procedures for replacing defects of partial resections using surrounding or distant fat tissues since 2000. These procedures are categorized as oncoplastic breast-conserving surgeries.

Fat necrosis is a subjective early as well as delayed complication that sometimes mimics local recurrence and ruins the quality of life due to pain and poor cosmetic result. However, there are no standard grading systems for assessing the fat necrosis [17]. While, the frequency and severity of fat necrosis are important issues that breast surgeons should explain to the patient, these data are not revealed well.

Annual mammography and physical examinations are appropriate follow-up procedures for patients who have undergone BCT [18]. Therefore, we assessed fat necrosis by mammographic findings and physical findings as skin changes, tumor formation, and subjective pain.

Patients and methods

A total of 1476 patients who underwent breast surgery from January 2000 to December 2012 were enrolled in the present study. The patients were followed for more than 5 years after breast surgery. A total of 393 (27%) patients underwent mastectomy and 1083 (73%) underwent BCT. Adjuvant therapies were adopted according to the guideline of the Japan Breast Cancer Society [19]. Most of the patients underwent whole-breast irradiation with 50–60 Gy as appropriate after BCS.

We attempted several new oncoplastic procedures after wide resection, in order to achieve good cosmetic results using surrounding breast tissue (pedicled fat flap) or a free dermal fat graft. Pedicled fat flaps include lateral epidermal fat flaps, inframammary adipofascial flap, and rotation of surrounding breast tissues. The lateral epidermal fat flap is an original surgical procedure from our institute [20], briefly described as follows. Triangle skin incisions were designed on lateral thoracoaxillary region. From the anterior incision, wide partial resection and axillary lymph node dissection were performed. After that, thoracoaxillary flap was made by a posterior incision. The skin of this flap was then denuded and inserted into the defect of partial resection. The blood supply of the lateral epidermal fat flap is kept via random epidermal vessels and rarely develops fat necrosis, even after irradiation therapies.

We adopted this procedure for wide resections of the lateral part of the breast, while the inframammary adipofascial flap and rotation of surrounding breast tissues were adopted for the case of partial resection of the inferior medial and superior lateral parts, respectively. The free dermal fat graft was obtained according to Kijima's procedure [21], which was adopted for cases of the partial resection of the median part and central part of the breast.

We reviewed the mammographic and physical findings, to classify the fat necrosis. We established grading criteria according to the report by Lovy [22] as follows: Grade (G) 0, no fat necrosis; G1, no symptomatic fat necrosis (mammographic dystrophic calcification); G2, mild symptomatic necrosis (mammographic dystrophic necrosis with tumor); G3, severe symptomatic necrosis (mammographic dystrophic necrosis with pain or skin change); and G4, symptomatic necrosis requiring surgical intervention. We categorized the findings of fat necrosis, for each mammogram from BCS to the time when the finding of fat necrosis was fixed. Final grading was compared among the following three groups: no replacement, pedicled flap and free dermal fat graft. In addition, the frequency and severity were compared among the three pedicled flap procedures.

Statistical analysis The frequency of fat necrosis was statistically analyzed using Fisher's exact test and the Chi-square test as appropriate (StatMate by ATMS, Tokyo, Japan).

Results

Changes in surgical procedures from 2000 to 2012

The changes in surgical procedures adopted from 2000 to 2012 are shown in Fig. 1. We achieved a high rate of BCS at a total rate of 73% over the study period and maximum rate of 88% in 2010 using oncoplastic procedures. We mainly adopted pedicled flap (417/1083; 39%) and free dermal fat flap (40/1083; 3.7%) (Fig. 1). The rate of BCS gradually decreased to 60% and total mastectomy with breast reconstruction increased to 10% in 2017 (data not shown). The patients characteristics of the three groups, (partial resection without no replacement, pedicled fat flap and free dermal fat graft) differed, because we selected the surgical procedure for each case according to the location, extension, histological type of breast cancer and patient's preference.

Incidence and severity of fat necrosis after BCS

Details of fat necrosis indicated by dystrophic calcification and physical findings are shown in Table 1. Among the 626

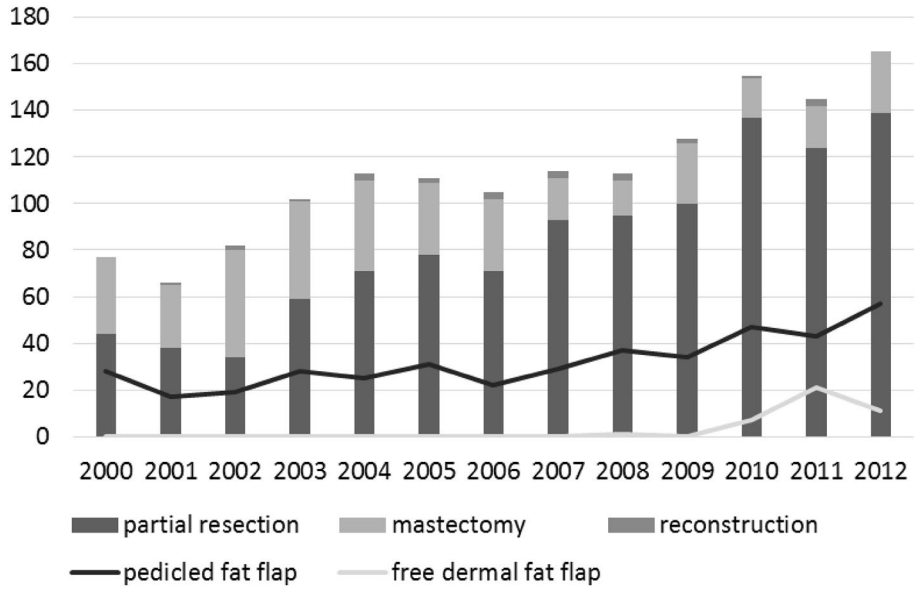

Fig. 1 Changes in surgical procedures since 2000 to 2012. We achieved high rate of breast-conserving surgery totally 73% with max rate of 88% in 2010, using oncoplastic procedures. Pedicled flap 417/1083 (39%) and free dermal fat flap 40/1083 (3.7%) were plotted, respectively

Table 1 Incidence and severity of fat necrosis

	No. of cases	G0	G1	G2	G3	G4	Total
No replacement	626	597 (95%)	22 (3.5%)	7 (1.1%)	0 (0%)	0 (0%)	29 (4.6%)
Pedicled fat flap	417	349 (84%)	35 (8.4%)	21 (5.0%)	10 (2.4%)	2 (0.5%)	68 (16%)
Lateral epidermal fat flap	276	243 (88%)	22 (8.0%)	9 (3.3%)	1 (0.4%)	1 (0.4%)	33 (12%)
Inframammary adipofascial flap	25	11 (44%)	6 (24%)	3 (12%)	5 (20%)	0 (0%)	14 (56%)**
Rotation of surrounding tissue	116	95 (82%)	7 (6.0%)	9 (7.8%)	4 (3.4%)	1 (0.9%)	21 (8%)
Free dermal fat graft	40	0 (0%)	6 (15%)	24 (60%)	5 (13%)	5 (13%)	40 (100%)*

*Significantly higher than pedicled fat flap ($p < 0.01$ by χ^2 test)

**Significantly higher than lateral epidermal fat flap ($p < 0.01$) and rotation of surrounding tissue ($p < 0.01$ by χ^2 test)

patients who underwent partial resection with no replacement for the defect, G1–G2 fat necrosis was seen in 29/626 (4.6%), while the incidence of fat necrosis of pedicled fat flap and free dermal fat graft was 68/417 (16%) and 40/40 (100%), respectively, showing a significant difference ($p < 0.01$). Furthermore, the incidence of G3-G4 fat necrosis was significantly higher with free dermal fat grafts, (25%; 10/40) than with pedicled fat flap (2.9%; 12/417) ($p < 0.01$). Among the pedicled flaps, the incidence of fat necrosis of inframammary adipofascial flap was 56% (14/25) which was higher than that with lateral epidermal fat flap (12% ; 33/276) ($p < 0.01$), and rotation of surrounding breast tissues at 8% (21/116) ($p < 0.01$). The incidence of G3 fat necrosis was also high at 20% (5/25) in inframammary adipofascial flaps.

Progress of fat necrosis with free dermal fat graft

Mammographic changes

Dermal fat grafts can be detected by mammography as a round density which is same or slightly higher than fatty tissue at 1 year after the surgery (Fig. 2). Then, lineal coarse calcifications appeared 2–3 years after surgery (G1), and the number of calcifications gradually increased (G2) in accordance with the development of the hard mass. Patients sometimes suffered from pain, skin changes and were anxious about local recurrence. These patients were categorized as having grade 3 necrosis.

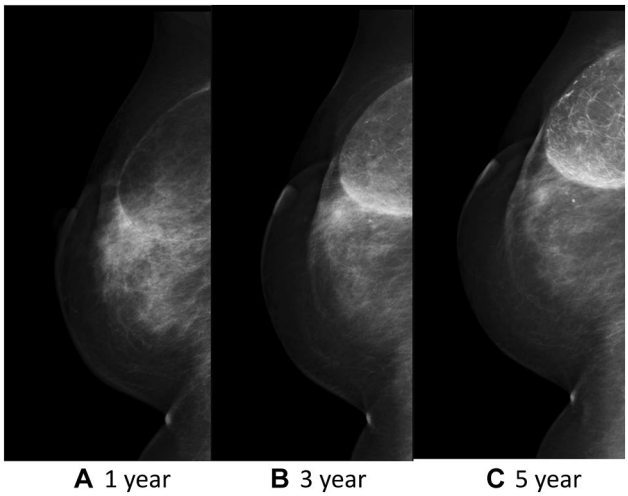

Fig. 2 Changes of mammographic findings for dermal fat graft. **a** Round density same as fatty tissue was seen in 1 year after the surgery (G0). **b** Then, lineal coarse calcifications appeared in 3 years later (G1). **c** The number of calcifications were gradually increased in 5 years (G2) in accordance with developing hard mass

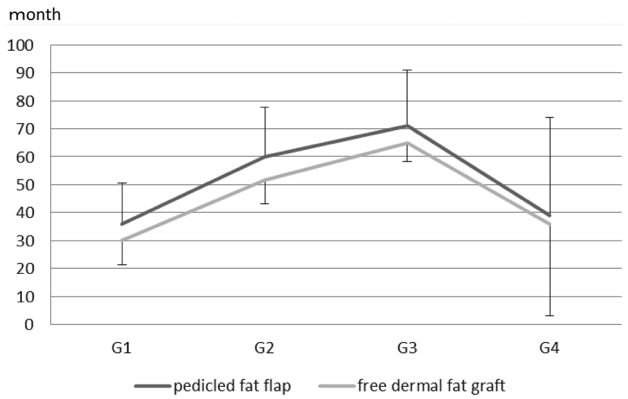

Fig. 3 The progression time of fat necrosis occurred in free dermal fat graft and pedicled fat flap. The mean months of G1–G4 fat necrosis was 30 ± 8.7, 52 ± 8.2, 65 ± 6.6, and 36 ± 33 months, respectively. The progression time of pedicled flap is as same as free dermal fat graft with 36 ± 15, 60 ± 18, 71 ± 20, and 39 ± 33 months, respectively

Progression of severity

The timeline for the progression of fat necrosis that occurred in free dermal fat grafts is shown in Fig. 3. The mean time until developing G1–G4 fat necrosis was 30 ± 8.7, 52 ± 8.2, 65 ± 6.6, and 36 ± 33 months, respectively. The progression time of pedicled flap is as same as free dermal fat graft with 36 ± 15, 60 ± 18, 71 ± 20, and 39 ± 35 months. The progression time until G4 fat necrosis varied from 3 to 72 months, because G4 necrosis includes both of early complication with infection and delayed fat necrosis.

Surgical management for G4 fat necrosis

Surgical management for fat necrosis was performed as follows. Under local anesthesia, we removed the necrotic fat graft and made a debridement for fibrous tissue as extensively as possible (Fig. 4). The wound was opened and waited to close as a secondary healing. The granulation filled the defect after around 5 months. These patients required long-term treatment for their wound.

Discussion

Fat necrosis was initially reported as a response to an irritant such as trauma. And fat necrosis after BCT was first reported by Clerk et al. [23], mimicking the local recurrence of breast cancer. The symptoms of fat necrosis can be classified into early- and delayed-phase symptoms. In the early phase, the fat changes into resolved necrotic tissue and is sometimes accompanied by infection, and makes inflammatory change in the skin. In such case, drainage operation must be performed quickly, while most of patients with fat necrosis after BCT were recognized in delayed phase. Necrosis or apoptosis of adipocytes and infiltration of the inflammatory cells occurred [17], and we can see the mixed feature of oil formation and fibrosis. It is difficult to diagnose and classify the delayed-phase fat necrosis. Therefore, mammographic finding of calcification that is named dystrophic calcification in the standard breast imaging reporting and data system (BI-RADS) is reported to be useful to classify the fat necrosis [22].

We showed the incidence of fat necrosis of BCT with no replacement was low at 4.6% (39/626) and rarely developed G3 or G4 fat necrosis. However, the cosmetic results were impaired according to several factors such as extent of partial resection, location of the tumor, and skin invasion. We selected oncoplastic procedures for each patient to ensure good cosmetic results, although we could not show the indication of each procedure and objective cosmetic result of each case.

Fat necrosis in the early phase was rare and the cosmetic results were satisfactory for a few years. Therefore, we considered the formation of fat necrosis to be potentially related to radiation therapy. Recently, there have been some reports describing the incidence of fat necrosis after accelerated partial breast irradiation (ABPI). In these reports, fat necrosis occurs in around 20% of cases after irradiation [24, 25].

We showed the timeline of the progression of fat necrosis in cases of free dermal fat grafts. Calcification developed 24–36 months after the surgery and tumors were palpable, and in some cases tenderness and pain had developed. As Kijima et al. [21] reported, early complications of free dermal fat graft were low, we were satisfied with the cosmetic

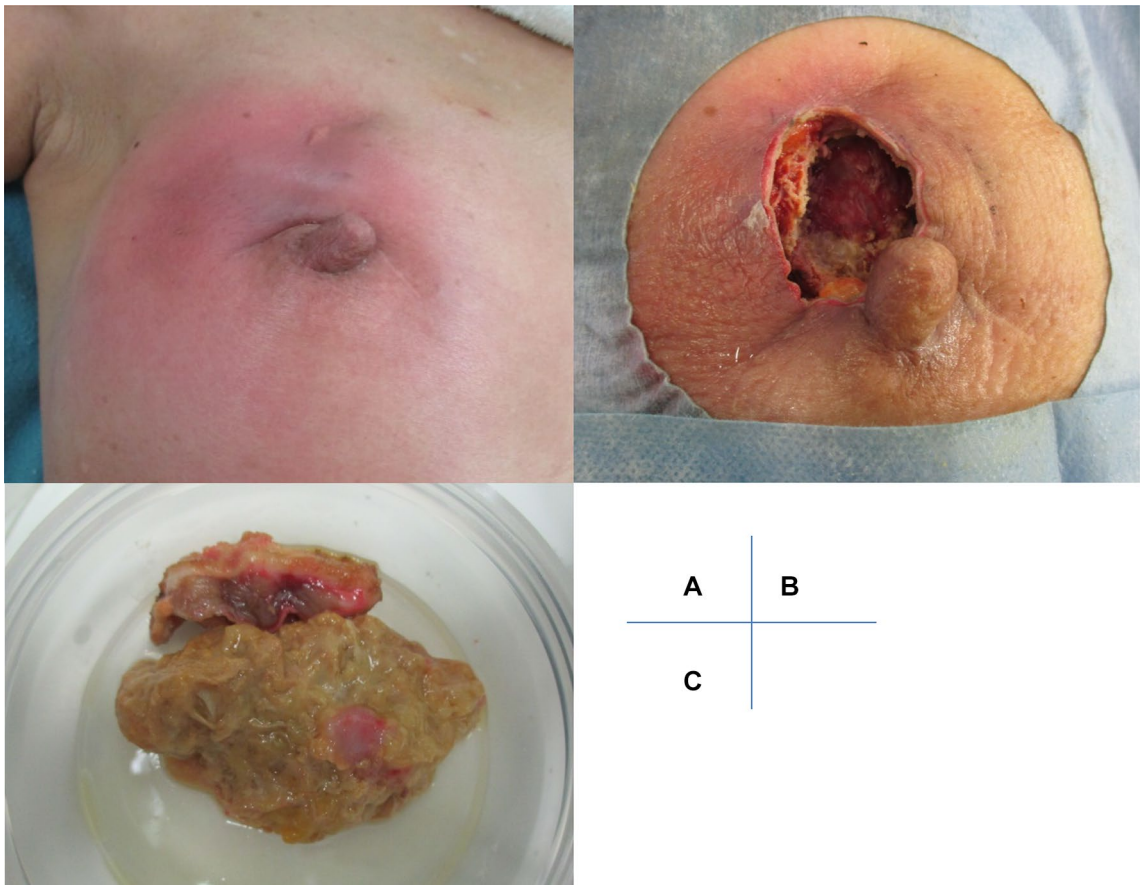

Fig. 4 Surgical management for fat necrosis of dermal fat graft. **a** The patients with G4 fat necrosis suffered from inflammatory change with pain and fever. **b** We removed necrotic fat graft (**c**) and made a debridement for fibrous tissue as extensively as possible. The wound was opened and waited to close as a secondary healing

results for 1–2 years after surgery without any signs for fat necrosis, but most of cases show G2–3 fat necrosis in the delayed phase. These findings suggested fat necrosis might be affected by irradiation after BCS.

Concerning the patients with pedicled fat flaps, fat necrosis was seen in part of fat graft. The fat with a poor blood supply became necrotic just as with the free dermal fat graft. The progression of dystrophic calcification was almost the same as with the free dermal fat graft (Fig. 3), while we recognized low rate of fat necrosis in the cases treated with a lateral dermal fat flap even though they underwent irradiation as same as other cases. This surgical procedure was an original one established at our institute. The blood supply was preserved via random epidermal vessels. We showed in the present study that fat grafts replacing defects due to BCT require a good blood supply.

The frequency of BCT has decreased in recent years, and the indication of total mastectomy with immediate breast reconstruction has increased rapidly. This paradigm shift has been due to late complications of BCT as fat necrosis, and technological progress with breast reconstructions. In addition, concern over hereditary breast cancer was elevated in many physicians, which is affecting the selection of mastectomy increased. However, irradiation after the mastectomy is also a factor in increasing the complications of reconstructive surgery [26]. Therefore, we adopted oncoplastic breast-conserving surgery for the advanced patients requiring irradiation rather than breast reconstruction using artificial implant.

In conclusion, breast-conserving oncoplastic surgery carries a risk of fat necrosis as a late complication. Patients should be informed about the incidence rate and potential severity of fat necrosis by each procedure. We should select fat grafts with a good blood supply to replace the defect of BCT.

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Compliance with ethical standards

Conflict of interest The authors have declared no conflicts of interest.

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