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Original Article

# A new indication and surgical procedure to reduce fat necrosis after breast-conserving surgery using an inframammary adipofascial flap

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ABSTRACT

*Background:* There is little information on the risk factors for fat necrosis after breast-conserving surgery using an inframammary adipofascial flap (IAF).
*Methods:* We conducted a retrospective cohort study from a single institution evaluating the risk factors for fat necrosis after breast-conserving surgery using an IAF (n = 41) performed from 2005 to 2020 for newly diagnosed stage 0–2 breast cancer or phyllodes tumor.
*Results:* Age (≥50 years of age vs. <50 years of age), mammographic density (fatty vs. other) and operation period (before vs. after revision of surgical procedure and patient indication) were significantly associated with fat necrosis (p = 0.006, p = 0.04 and p = 0.02, respectively).
*Conclusion:* Our study suggested that the use of an IAF with crescent dermis and selection of appropriate cases for IAF after breast-conserving surgery may be useful for the purpose of reducing fat necrosis. Further study is needed.


## 1. Introduction

Breast-conserving therapy has become the standard treatment for early-stage breast cancer, and the goal of breast-conserving surgery is to maintain both good cosmetic results and oncological safety.[1] However, it is well-known that breast-conserving surgery in the lower portion results in poor cosmetic results.[2] In order to improve the cosmetic results of breast-conserving surgery for breast cancer in the lower portion, breast oncoplastic surgery with the application of a reduction technique, which was originally used in the field of aesthetic plastic surgery, has emerged in the 1990s in Europe and the United States.[3,4] There are two types of oncoplastic surgery: the volume replacement technique, which uses extramammary tissue to repair breast defects after breast-conserving surgery; and the volume displacement technique, which applies the aforementioned reduction technique to repair defects using intramammary tissue.[5] Since the Japanese breast is smaller than that of Westerners, the volume replacement technique is the preferred method. In order to improve the cosmetic results of the treatment of Japanese breast cancer in the lower portion, we started breast-conserving surgery using an inframammary adipofascial flap (IAF), which is a volume replacement technique.[6] In this technique, the fatty fascial valve is raised from the epigastric region caudal to the inframammary fold (IMF) to create a tongue-like shape for mammoplasty. This was first reported in 1992 by Sakai et al.[7] We have reported IAF as a relatively simple procedure that can be performed by breast surgeons without the aid of plastic surgeons, and which can contribute to the improvement of the cosmetic results of the treatment of breast cancer in the lower portion in Japanese patients.[8] Recently, Nakada et al reported that IAF was associated with a significantly higher incidence of fat necrosis after breast-conserving oncoplastic surgery.[9] Therefore, in this study, we aimed to investigate the risk factors for fat necrosis in patients who underwent breast-conserving surgery using an IAF and to clarify the indication of breast-conserving surgery using an IAF.

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## 2. Methods

We conducted a retrospective cohort study focusing on fat necrosis in patients who underwent breast-conserving surgery using an IAF. This study was approved by the Ethics Committee of Mie University (registration no: H2021-037). This study was conducted in accordance with the ethical principles of the Declaration of Helsinki.

Forty-one patients who underwent breast-conserving surgery using an IAF at Mie University Hospital from February 2005 to August 2020 were included in this study. During this study period, we recognized that some patients experienced fat necrosis in the affected breast. Therefore, we revised the technique and the indication from December 2015. We divided the patients into the pre-revision group (cases performed between 2005 and 2014) and the post-revision group (cases performed after 2015). We investigated the association of fat necrosis with various clinical and pathological factors. Breast density on mammography was classified by three certified experts into four categories: extremely dense breast tissue; heterogeneously dense; scattered fibroglandular; and fatty.[10] We used two methods to evaluate fat necrosis. The first method was described by Lövey et al[11]: grade 0, no fat necrosis; grade 1, only heterotrophic calcification on mammography; grade 2, palpable mass without pain; grade 3, palpable mass with pain; grade 4, fat necrosis requiring surgical intervention. In the second method, the mass size of fat necrosis in grade 2–4 cases was evaluated by mammography and ultrasonography.[12]

### 2.1. Surgical techniques

Pre-revision technique: A skin incision is made at the IMF. After partial mastectomy is performed, a skin valve of tongue-shaped fat and the anterior sheath of the rectus abdominis muscle are pulled up into the IMF. The skin valve is then inserted into the post-tumor excision area and secured to the surrounding breast tissue with absorbable sutures.[6]

Post-revision technique (IAF with crescent dermis): We made a tongue-shaped fatty fascial valve caudal to the chest wall with 2–3 cm of de-epithelialized crescentic skin attached to it (Figs. 1 and 2).

In the pre-revision technique, blood flow to the skin valve is nourished by perforators near the IMF, but the perforators are not directly identified at the time that the skin valve is made. Therefore, we hypothesized that some cases of fat necrosis may have occurred because the perforators were not preserved when the skin valve was made. Therefore, in order to avoid damaging the perforators, we decided not to detach the de-epithelialized skin from the abdominal wall in the IAF with crescent dermis. In addition, in the pre-revision technique, a 7-cm tongue-shaped skin valve must be created; however, in the IAF with crescent dermis, a 4-cm tongue-shaped skin valve can be created, which is simpler than the pre-revision technique. This may be useful for reducing the difference in technique among surgeons.

### 2.2. Patient indications

After the revision of the patient indications, we excluded patients older than 50 years of age and patients with fatty mammary glands on mammography.

### 2.3. Statistical analysis

We evaluated the differences in patient characteristics and the mass size of grade 2–4 fat necrosis between the pre- and post-revision groups using the chi-squared test or Student's t-test. All statistical analyses were performed using the SAS® JMP® Statistics software program (version 14.2, SAS®, USA). *P* values of $<0.05$ were considered to indicate statistical significance.

## 3. Results

The patient characteristics are shown in Table 1. The number of patients was 35 in the pre-revision group and 6 in the post-revision group. The mean follow-up period was 118 months (range, 28–192 months) in the pre-revision group and 31 months (range, 6–62 months) in the post-revision group. The mean age was 49 years (range, 26–70 years) in the pre-revision group. In the post-revision group, the mean age was 40 years (range 26–48 years), and all patients were younger than 50 years of age. Patients in the post-revision group were significantly younger than those in the pre-revision group ($p = 0.04$). In addition, there were no patients with fatty mammary glands on mammography in the post-revision group.

The incidence and severity of fat necrosis are shown in Table 2. The grades of fat necrosis in the 2 groups did not differ to a statistically significant extent.

The association of the mass size of grade 2–4 fat necrosis with various clinical or pathological factors is shown in Table 3. The mass size of grade 2–4 fat necrosis in patients of >50 years of age was significantly larger in comparison to those ≤50 years of age

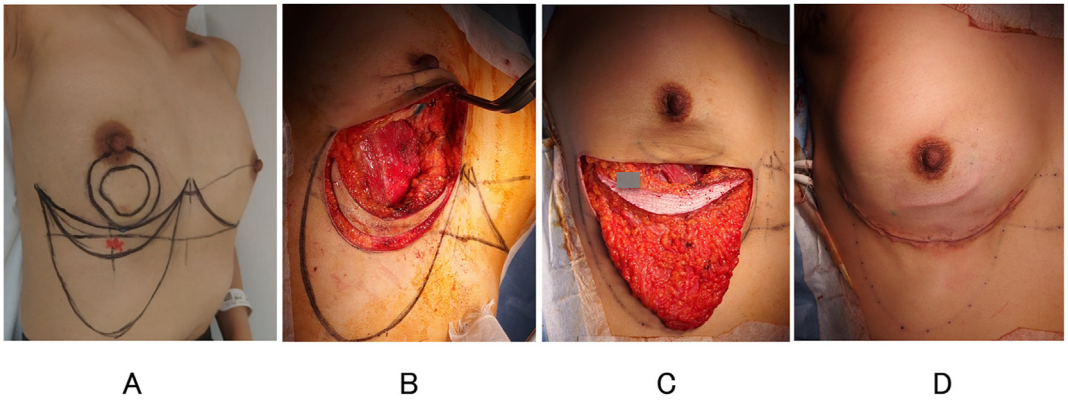


**Fig. 1.** The surgical procedures of the post-revision technique (IAF with crescent dermis): (A) The pre-operative design with the partial mastectomy area, pre-operative IMF, post-operative IMF, the area of the adipofascial flap, and the location of the perforators. (B) After partial mastectomy (C) A tongue-shaped adipofascial flap with crescent dermis. (D) After skin suture.

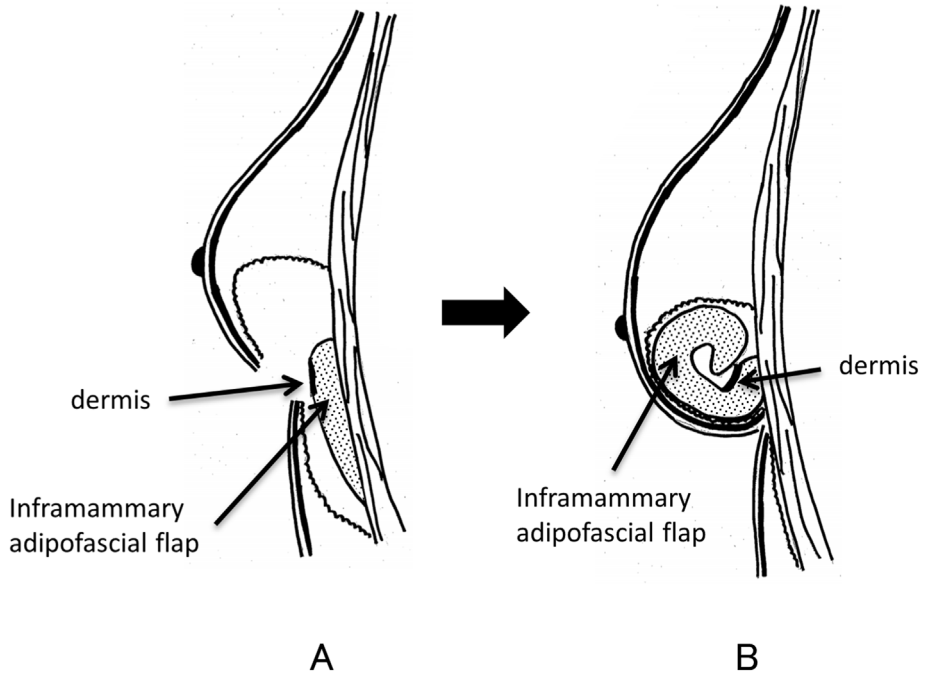


**Fig. 2.** Schematic illustration of the post-revision technique (IAF with crescent dermis): (A) De-epithelialization of the skin of the area between the pre-operative IMF and the post-operative IMF is performed and the area is used as a part of the IAF. (B) The area of the de-epithelialized skin below the IMF is not released from the chest wall. The flap is pulled up and inserted into the post-tumor excision area.

**Table 1**
Patient characteristics (n = 41).

| Characteristics | | Findings (n = 35) before revision | Findings (n = 6) after revision | P value (chi square test) |
|---|---|---|---|---|
| Age (y.o.) | median (range) | 49 (26–70) | 40 (26–48) | 0.04 |
| | ≦49 | 17 | 6 | |
| | 50≦ | 18 | 0 | |
| Body mass index | median (range) | 22.9 (16.6–36.1) | 21.2 (15.7–25.4) | 0.3 |
| | | 17 | 3 | |
| | <22 | 18 | 3 | |
| | 22≦ | | | |
| Mammographic breast density | fatty | 4 | 0 | 0.5 |
| | others | 31 | 6 | |
| Pathologic tumor size | phyllodes tumor or Tis | 14 | 2 | 0.1 |
| | T1 and T2 | 21 | 4 | |
| Axillary treatment | no axillary dissection | 31 | 6 | 0.1 |
| | axillary dissection | 4 | 0 | |
| Chemotherapy | yes | 8 | 2 | 0.6 |
| | no | 27 | 4 | |
| Hormonal therapy | yes | 9 | 3 | 0.2 |
| | no | 26 | 3 | |
| Radiotherapy | yes | 21 | 6 | 0.06 |
| | no | 14 | 0 | |

**Table 2**
Incidence and severity of fat necrosis.

| Severity of fat necrosis | No. of patients before revision | No. of patients after revision |
|---|---|---|
| Grade 0 | 10 | 3 |
| Grade1 | 9 | 1 |
| Grade2 | 6 | 1 |
| Grade3 | 1 | 0 |
| Grade4 | 9 | 1 |

(p = 0.006). There was no significant difference according to the body mass index. The mass size of grade 2–4 fat necrosis was significantly larger in patients with fatty mammary glands on mammography in comparison to that in other categories (p = 0.04).

**Table 3**
Association of mass size of grade 2–4 fat necrosis with various clinical or pathological factors.

| Characteristics | | Mean mass size (mm) | P value (Student's t test) |
|---|---|---|---|
| Age (y.o.) | ≦49 | 22.4 | 0.006 |
| | 50≦ | 33.9 | |
| Body mass index | <22 | 31.5 | 0.5 |
| | 22≦ | 28 | |
| Mammographic breast density | fatty | 41.2 | 0.04 |
| | others | 27.9 | |
| Pathologic tumor size | phyllodes tumor or Tis | 29.8 | 0.9 |
| | T1 and T2 | 29.3 | |
| Axillary treatment | no axillary dissection | 29.1 | 0.5 |
| | axillary dissection | 36 | |
| Chemotherapy | yes | 27.2 | 0.6 |
| | no | 30.3 | |
| Hormonal therapy | yes | 32.6 | 0.4 |
| | no | 28.2 | |
| Radiotherapy | yes | 27.9 | 0.3 |
| | no | 32.4 | |
| Operation period | before revision | 31.4 | 0.02 |
| | after revision | 16.3 | |

Regarding the study period, the mass size of grade 2–4 fat necrosis was significantly larger in the pre-revision group than in the post-revision group ($p = 0.02$).

## 4. Discussion

Obesity, postoperative radiation therapy, and scattered fibroglandular or fatty mammary glands have been reported as risk factors for fat necrosis after breast reconstruction.[2,13] In this study, we investigated the association of fat necrosis after breast-conserving surgery using an IAF with various clinical and pathological factors. Various reports have described methods for assessing fat necrosis; however, there is no standardized method.[14] In this study, we used both grade-based and size-based methods to evaluate fat necrosis. In the analysis by size-based methods, we only evaluated grade 2–4 fat necrosis because grade 1 fat necrosis is characterized by mammography changes alone and is not measurable.

Our study results demonstrated that patients under 49 years of age with non-fatty mammary glands were suitable for breast-conserving surgery using an IAF. In addition, this approach may be contraindicated for patients with fatty mammary glands because fat necrosis occurred in all patients with fatty mammary glands in our study. The IAF is a skin valve that raises the abdominal tissue; thus, fatty mammary glands and poor blood flow in the adipofascial flap are not synonymous. However, it is difficult to examine the blood flow in abdominal tissue preoperatively. Age and the mammographic breast density could be good indicators for choosing the indication of breast-conserving surgery using an IAF, since these factors can be checked preoperatively in all cases. In this study, there was no association between obesity and fat necrosis. The reason for this is that most of the patients in this study had a body mass index of ≤25, which is considered normal weight in other reports.

The intercostal artery perforator (ICAP) is one a volume replacement technique; the anterior intercostal artery perforator (AICAP) flap technique is a subtype of this technique.[15,16] In the IAF procedure, intraoperative confirmation of the perforators is not performed; however, it is a similar technique in that it uses the same perforators as the AICAP to maintain blood flow to the skin valve. AICAP can reliably preserve the perforators; however, the technique is somewhat difficult for a breast surgeon to perform alone. However, IAF is easier than AICAP and can be performed by a breast surgeon alone because the skin valve is inverted before the entry of the perforators. Fat necrosis after breast-conserving surgery is thought to be caused by the destruction of adipose tissue due to impaired blood circulation.[17] Therefore, securing blood flow to the skin valve is considered an important technique to prevent fat necrosis. In order to secure blood flow to the skin valve, it is effective not only to preserve the perforators but also to utilize the dermal vascular network.[18] Using the post-revision technique (IAF with crescent dermis), we were able to preserve the fixed parts of chest wall where the perforators enter the skin valve. Furthermore, we can make the skin valve more easily in comparison to the pre-revision technique. The de-epithelialized skin also helps to compensate for the volume. Since the mass size of grade 2–4 fat necrosis was significantly smaller in the post-revision group, the risk of fat necrosis may be reduced by revising both the indication and the surgical technique. Based on these results, we believe that by the selection of appropriate cases and an IAF with crescent dermis will help to reduce the rate of postoperative fat necrosis and improve cosmetic results.

We did not check the perforating branch intraoperatively when performing this procedure. However, the location of the perforating branch around the IMF was checked preoperatively by ultrasonography. Subcutaneous fat in very thin women is often very thin, and we think ultrasonography is useful for confirming how much fat can be secured. Therefore, we also check the thickness of the IAF by ultrasonography and try to estimate how much volume can be obtained.

Although age and mammographic density were risk factors for fat necrosis in this study, no patients over 50 years of age were enrolled in the post-revision group of this study. Therefore, whether IAF should be performed on dense breasts in patients over 50 years of age is a matter for future study.

The present study was associated with some limitations. The number of cases was relatively small, and the number of patients in the post-revision group was extremely small. Therefore, the accumulation of further cases is necessary. In the present study, we only performed univariate analyses and did not perform multivariate analyses due to small sample size. Therefore, it may not be possible to make statistically robust inferences. It has been reported that the mean period until the detection of fat necrosis was 21.1 months from surgery[12]; thus, we cannot deny the possibility that the short follow-up period (mean, 31 months) in the post-revision group in this study resulted in the low frequency of fat necrosis, and further

follow-up is necessary. In this study, the indication and surgical technique were revised simultaneously; thus, it is unclear which of the changes reduced the frequency of fat necrosis. In addition, because there were multiple surgeons rather than a single surgeon, there may have been differences among the surgeons. The assessment of fat necrosis was performed retrospectively based on medical records, which may not be as accurate as a prospective study. There were some cases in the earlier study period that did not receive radiotherapy after breast-conserving surgery. Since the omission of breast radiotherapy is not recommended, caution should be exercised when interpreting the results of this study. The present study has two aims: to identify risk factors for fat necrosis and present a new method. It is possible that we have not been able to present sufficient data on risk factors. However, we thought it would be better to report our revised indications and techniques as soon as possible because we first reported the use of an IAF after breast-conserving surgery in 2007.[6]

In conclusion, our study suggested that the performance of the IAF technique with crescent dermis and selection of appropriate cases for IAF after breast-conserving surgery may be useful for reducing fat necrosis. Further study is needed.

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