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# Clinical progression following acellular dermal matrix use for volume replacement after breast-conserving surgery

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## Abstract

**Background** The cosmetic outcomes of breast-conserving surgery (BCS) have recently gained increasing attention, and surgeons are exploring the use of the acellular dermal matrix (ADM) as a safe and effective method of breast reconstruction. This study evaluated the clinical progress of patients with breast cancer following the application of sheet-type ADM for breast reconstruction after BCS.

**Methods** This retrospective study included 137 patients who underwent BCS using ADM at a single center between October 2019 and October 2021. During surgery, sheet-type ADM was folded and inserted into the excised defects. Complications and cancer recurrence were evaluated during surveillance follow-up until December 2023, and maintenance of the inserted ADM was quantitatively compared using volume analysis of the first and last follow-up computed tomography (CT).

**Results** Of the 137 evaluated patients, 16 (11.6%) had minor complications, and 17 (12.4%) underwent biopsy during the surveillance period. One patient was diagnosed with recurrence. ADM volume was measured in 55 patients. The mean volume reduction between the first and last CT scans was $1.81 \pm 2.06$ cm$^3$ (a decrease of $17.42 \pm 19.82$%), which was statistically significant ($p < 0.001$).

**Conclusions** The insertion of ADM after BCS is a safe and effective method for addressing volume defects, even though a slight reduction occurs in ADM volume.

**Keywords** Acellular dermal matrix, Breast cancer, Breast-conserving surgery

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## Background

Breast-conserving surgery (BCS) is a common surgical procedure performed in South Korea and is generally considered a safe approach for preserving the breast [1]. During BCS, in addition to tumor resection with adequate margins, many surgeons focus on the cosmetic aspects of the intervention, namely, maintaining breast shape [2]. These cosmetic defects can be prevented using the surrounding tissue of the remaining breast tissue after BCS for reconstruction. However, as Korean women have relatively small breasts, achieving satisfactory cosmetic results using the volume displacement method is challenging [3–5].

To compensate for the lack of surrounding breast tissue, various filling materials after BCS have been introduced. Synthesis fillers such as Vicryl mesh are associated with a high complication rate, while hyaluronic acid and collagen fillers can be gradually absorbed into the body [6–8]. Acellular dermal matrix (ADM) is another option that can effectively replace the volume lost due to BCS. ADM is derived from human skin tissue that has undergone decellularization [9]. This process removes cells and immunogenic substances to prevent immune rejection and inflammation after transplantation. The remaining connective tissue scaffold serves as a matrix for re-epithelialization, neovascularization, and infiltration of fibroblasts [9]. ADMs are widely used in implant-based breast reconstruction to supplement cosmesis and reduce the risk of capsular contraction of the implant, and studies have demonstrated their safety and effectiveness [10–13].

The use of ADM as a volume filler in BCS is currently being explored; however, a few reports have evaluated its effectiveness in BCS [14, 15]. Paik et al. and Suh et al. applied an ADM in patients with breast cancer undergoing BCS and showed that this method was easy, safe, and yielded satisfactory cosmetic outcomes [14, 15]. However, to the best of our knowledge, maintenance of ADM volume has not been quantitatively evaluated during follow-up surveillance. In this study, the outcomes of inserted ADM were quantitatively evaluated for the first time using computed tomography (CT) volumetric analysis, while complications and cancer recurrence were assessed during follow-up surveillance.

## Methods

### Ethics consideration

The Institutional Review Board of the Ulsan University Hospital approved the study protocol (IRB number: 2023-01-003-001).

### Patients

We retrospectively enrolled 137 patients who underwent BCS followed by ADM at a single institution between October 2019 and October 2021. ADM insertion was performed at our institution after providing a thorough explanation of the procedure and obtaining informed consent from patients who met the following inclusion criteria: tumor size ≥ 2 cm based on imaging or clinical suspicion (due to diffuse microcalcification, multifocal disease, etc.), small overall breast volume, or patient concerns regarding breast deformity following surgery. Regardless of tumor size and location, patients who underwent insertion of a 5 × 7-cm sheet-type ADM were included in the study.

Volumetric analyses were performed in patients who underwent CT, including the breast within the scan range within 1 month and 20 months postoperatively. Patients with postoperative fluid or air collection in the operation bed, previous history of breast surgery, history of implant insertion, and inadequate follow-up CT were excluded from the volume analysis (see Additional file S1).

Demographic data, histological type, tumor stage, tumor location, specimen volume, and adjuvant radiotherapy were recorded. Specimen volume was converted to specimen weight based on pathological reports [16].

Complications associated with surgery were recorded during the surveillance follow-up period up to December 2023. Lesions assessed as Category 4 A Breast Imaging Reporting and Data System [17] or greater were detected in surveillance imaging follow-up studies, and the results of the pathological analysis of these lesions were reported.

### Surgical technique

A 5 × 7-cm sheet-type ADM (CGderm®, CGBIO Inc., Seongnam, Korea) was used. One sheet was used for each patient.

The patients received intravenous cephalosporin as preoperative and postoperative antibiotic therapy, which is the protocol used for all patients undergoing breast cancer surgery.

Preoperatively, an ADM was immersed in sterile normal saline. The size of the incision was determined based on the location and size of the tumor, and the mass was excised to achieve a negative margin. In the excision cavity, the breast tissue was resected for frozen biopsy. After confirming the negative results of the frozen biopsy, the fibroglandular tissue was separated from the skin, and the breast tissue was repositioned. First, tissue re-approximation was performed to close the glandular defect after tumor excision. Then, the ADM was inserted into the area of the defect cavity that could not be closed, and if necessary, the ADM was folded once to fit the size of the defect (Fig. 1). The ADM was fixed to the surrounding tissue using Vicryl 2 – 0, and the area was examined to ensure there was no dimpling or convex increase of the skin. To protect the ADM, the subcutaneous fat overlying

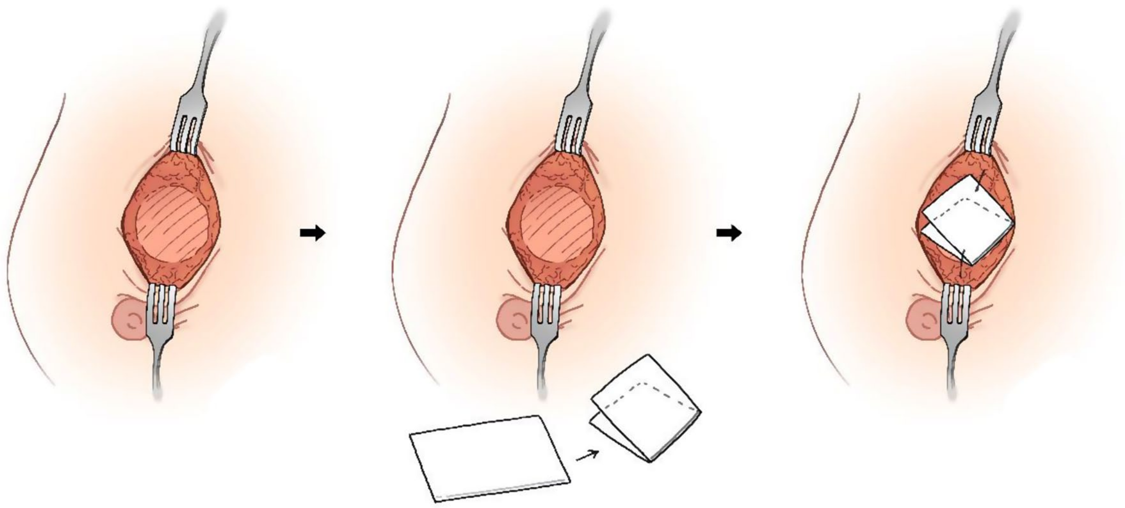

**Fig. 1** Acellular dermal matrix (ADM) insertion method

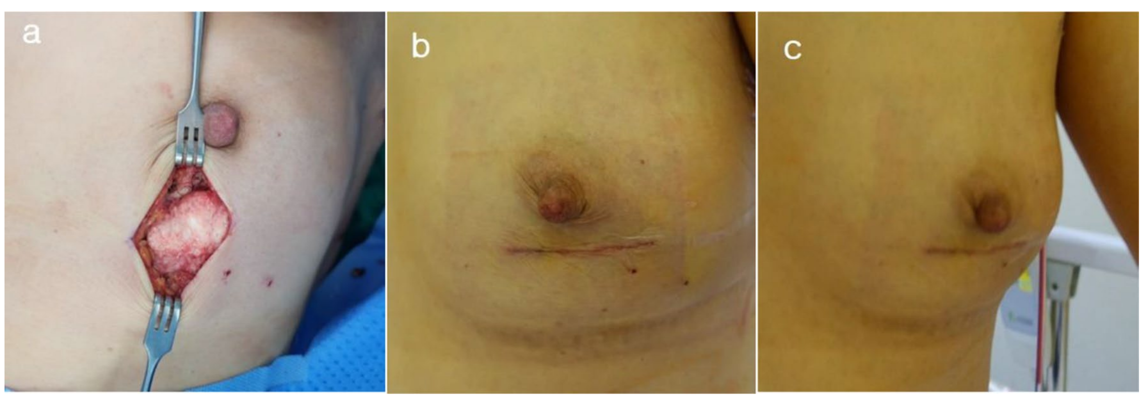


**Fig. 2** Intraoperative and postoperative photographs. A 53-year-old woman with multifocal invasive ductal carcinoma in the lower portion of left breast underwent breast-conserving surgery and acellular dermal matrix (ADM) insertion. **a**) Intraoperative photograph demonstrating the placement of ADM within the excision defect. (**b-c**) Postoperative evaluation in the sitting position shows preservation of breast contour with no visible deformity

the ADM was approximated, and the skin was then closed (Fig. 2).

A Jackson–Pratt (JP) drain was inserted for seroma drainage, if necessary, as determined by the surgeon. The JP drain was removed after 2–3 days when the drain volume was < 30 cc.

### ADM volume analysis

The first CT was used for planning radiation therapy, while the final CT was part of the routine follow-up for surveillance. The patients underwent both CT scans in the supine position.

Volumetric analyses were performed using Siemens Syngo.via VB 30 B (Siemens Healthcare, Erlangen, Germany). Image analyses were performed with the joint consultation of a breast radiologist with 12 years of experience and a breast surgeon with 6 years of experience.

ADM pockets were identified and delineated every 3–4 slices on transaxial pre-contrast CT scanning images. The software calculates the volume semi-automatically following the line defined by the radiologist. This analysis was performed using CT images obtained at 1 month and the last postoperative CT (Fig. 3).

### Statistical analysis

Statistical analysis was performed using IBM SPSS Statistics for Windows, version 21.0 (IBM Corp, Armonk, NY, USA). Statistical significance was established at a P-value of < 0.05. ADM volume was compared between the first and last CT using a paired t-test.

## Results

The characteristics of the 137 patients included in the study are summarized in Table 1. Their mean age was 51.4 ± 7.6 years, weight was 59.0 kg, and body mass index was 23.3 kg/m$^2$. The tumor locations were the upper outer quadrant, upper inner quadrant, lower outer quadrant, lower inner quadrant, and central location in 56, 35,

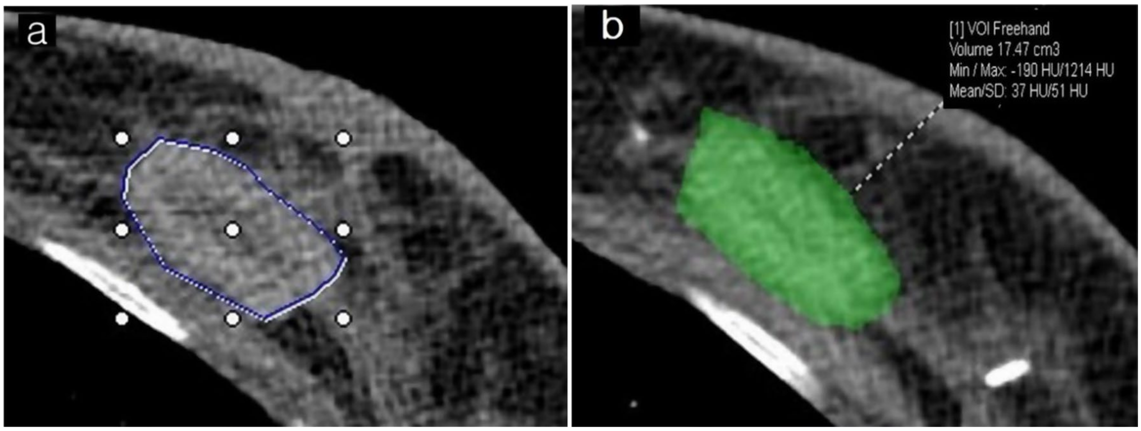


**Fig. 3** Application of the volume analysis tool. (**a**) The reader manually draws a line every three or four slices through the acellular dermal matrix (ADM) pocket. (**b**) The software automatically segments the ADM pocket volume

30, 8, and 9 patients, respectively. Of the 137 patients, 132 underwent adjuvant radiotherapy. The mean volume of the surgical specimen was 26.68 $cm^3$.

Complications associated with ADM use included seroma (the most common complication), hematoma, and redness in 10 (7%), 5 (3.6%), and 1 (0.7%) patients, respectively, at the first outpatient clinic visit. None of the included patients required reoperation for major complications or ADM removal.

Overall, 17 (12%) patients underwent biopsy when a Category 4 A lesion was detected in the ipsilateral breast during the surveillance follow-up (Table 2). Among them, the biopsy results of 16 patients were benign, and only 1 patient was diagnosed with recurrence. The patient who had recurrence refused adjuvant radiotherapy and chemotherapy after the first surgery and relapsed after 6 months. Suspicious findings on mammography and ultrasonography were noted, and a more definite lesion was observed on breast magnetic resonance imaging (MRI) (Fig. 4). No interval cancers were detected during follow-up.

In total, 55 patients were included in the volume analysis (see Additional fileS2). All patients included in the analysis received adjuvant radiation therapy.The mean follow-up interval between CT was 790 days (range, 674–903 days). The average ADM volume was $10.39 \pm 2.45$ $cm^3$ (range, 6.02–13.69) and $8.58 \pm 2.86$ $cm^3$ (range, 3.41–13.09) at the first and last CT, respectively. A significant mean difference was found in ADM volume ($1.81 \pm 2.06$ $cm^3$) between the first and last CT ($p < 0.001$).

## Discussion

This study quantitatively analyzed changes in ADM volume to determine the effectiveness of ADM insertion after BCS. The volume decreased by a mean of 1.81 $cm^3$ during a mean follow-up period of 790 days. Several studies have discussed the reason for this decrease. For instance, Qiu et al. [18] reported that e-beam irradiation sterilization interferes with the collagen matrix of ADM. Other studies have also reported that gamma and e-beam irradiation used for sterilization accelerates the rate of collagen fiber degradation and fragmentation in ADM [19, 20]. The increased rates of degradation and fragmentation compromise the tensile strength of ADM [19, 20]. As most patients undergoing BCS receive radiotherapy, some shrinkage of the ADM is expected, and understanding the interaction between radiation and ADM can aid in treatment planning.

The reduction in ADM volume observed over time should be considered in the context of long-term cosmetic outcomes. However, this decrease is unlikely to significantly impact overall breast volume. In patients who received radiotherapy following standard breast-conserving surgery, a reduction in total breast volume was noted. Cho et al. and Chung et al. reported a 17.6% decrease in the volume of the lumpectomy cavity and a 5% decrease in the tumor bed volume in patients who underwent radiotherapy [21, 22]. Considering the decrease in breast volume associated with radiotherapy, the reduction in ADM volume is unlikely to have a substantial effect on aesthetic outcomes. Nonetheless, as a decrease in ADM volume was observed over time, it is essential for patients to evaluate cosmetic outcomes during regular follow-up visits. Future studies should extend the follow-up period to enable a more comprehensive evaluation.

The use of ADM is associated with potential complications. In this study, 16 (11.6%) patients exhibited minor complications, mainly seroma, as also reported in previous studies [23, 24]. The incidence of seroma in patients undergoing conventional BCS is 9–11% [25, 26],

**Table 1** Characteristics of included patients

| Characteristics | |
|---|---|
| Age (years) | 51.4 ± 7.6 (27–69) |
| Height (cm) | 159 ± 4.9 (147–169) |
| Weight (kg) | 59.0 ± 8.3 (35.0–84.8) |
| BMI | 23.3 ± 3.1 (15.3–31.6) |
| T stage | |
| ypT0 | 4 |
| pTis/ypTis | 30 (29/1) |
| pT1/ypT1 | 72 (71/1) |
| pT2/ypT2 | 31 (29/2) |
| Pathology | |
| DCIS | 29 |
| IDC | 99 |
| ILC | 4 |
| others | 5 |
| Location | |
| Upper outer quadrant (UO) | 56 |
| Upper inner quadrant (UI) | 35 |
| Lower outer quadrant (LO) | 30 |
| Lower inner quadrant (LI) | 8 |
| central * | 8 |
| Adjuvant radiotherapy | |
| Yes | 132 |
| No | 5 |
| Specimen | |
| Weight (g) | 25.88 |
| Estimated volume ($cm^3$)** | 26.68 |

Values are presented as mean ± standard deviation (range)

BMI, body mass index; DCIS, ductal carcinoma in situ; IDC, invasive ductal carcinoma; ILC, invasive lobular carcinoma; P, pathologic T staging; ypT, pathologic T staging following neoadjuvant chemotherapy

* Central was defined as cancer within 1 cm of the nipple or subareolar lesion

** In the pathology report, the weight of the specimen was described. According to the breast density (ρ) on each patient's mammography, the specimen volume was calculated using the following equation: breast volume = breast weight/ρ (ρ = 0.916 g/mL for pattern A, ρ = 0.944 g/mL for pattern B, ρ = 0.972 g/mL for pattern C, ρ = 1.0 g/mL for pattern D) [16]

indicating that ADM use in this study was not associated with an increased risk of complications. One patient experienced a suspected infection that improved after 3 days of oral antibiotic treatment. None of the patients required ADM removal. Consistent with previous studies [25, 26], the present results indicate that this is a safe method.

During postoperative surveillance using imaging modalities such as ultrasound (US), visibility may be limited by the fibrogenetic activity induced by the ADM [15, 27–29]. The inserted ADMs appear as well-circumscribed masses with a density similar to that of the fibroglandular tissue on mammography and are iso- or hypoechoic on US; therefore, ADMs may interfere with the detection of cancer recurrence [9, 15, 19, 28]. An et al. reported that breast MRI was more effective than mammography or US for detecting ipsilateral local tumor recurrence in patients who underwent BCS with ADMs, despite postoperative changes caused by ADMs [30, 31]. The patients in this study were examined using breast MRI and US according to the follow-up protocol of our hospital, which includes breast MRI or US every 6 months for 5 years postoperatively. Surveillance examination detected a Category 4 A lesion in the ipsilateral breast of 17 patients, and one patient was diagnosed with recurrence. In this study, all 17 Category 4 A lesions were identified by US, with 6 and 1 detected by MRI and mammography, respectively. Recurrence was observed on US, MRI, and mammography.

This study had some limitations. First, it was a single-center retrospective study. Second, the included patients exhibited heterogeneity due to the inclusion of individuals from a clinical practice environment. As a result, the effects on the quantitative changes and stability of the ADM, which are the focus of this study, may be minimal. Third, this study did not assess cosmesis or subjective satisfaction. Previous studies have utilized a subjective ten-point scale, reporting high levels of patient satisfaction with the cosmetic outcomes [15]. Fourth, not all patients were included in this study, and only 55 patients underwent examination for a change in ADM volume. Many patients had a short postoperative period for measuring volume changes. Future studies should be large-scale, long-term, and prospective in nature, incorporating comprehensive assessments of cosmesis and patient satisfaction.

**Table 2** Biopsy on subsequent follow-up examination

| | Pathology | Imaging modality | | | |
|---|---|---|---|---|---|
| | | **Mammography** | **Ultrasonography** | **Magnetic resonance imaging** | **Computed tomography** |
| | **Benign (16)** | | | | |
| 1 | Fat necrosis | No | **Yes** | **Yes** | No |
| 2 | Fibrocystic change | No | **Yes** | No | No |
| 3 | Fibrocystic change | No | **Yes** | **Yes** | No |
| 4 | Stromal fibrosis | No | **Yes** | No | No |
| 5 | Fat necrosis | No | **Yes** | **Yes** | No |
| 6 | Stromal fibrosis | No | **Yes** | No | No |
| 7 | Fibrocystic change | No | **Yes** | No | No |
| 8 | Fibrocystic change | No | **Yes** | No | No |
| 9 | Interlobular fibrosis | No | **Yes** | No | No |
| 10 | Interlobular fibrosis | No | **Yes** | No | No |
| 11 | Interlobular fibrosis | No | **Yes** | **Yes** | No |
| 12 | Fibrocystic change | No | **Yes** | No | No |
| 13 | Fibroadenoma | No | **Yes** | No | No |
| 14 | Stromal fibrosis | No | **Yes** | **Yes** | No |
| 15 | Fibrocystic change | No | **Yes** | No | No |
| 16 | Stromal fibrosis | No | **Yes** | No | No |
| | **Malignant (1)** | | | | |
| 1 | Invasive ductal carcinoma | **Yes** | **Yes** | **Yes** | **Yes** |

Yes: The suspected lesion is visible in the imaging modality. No: The suspected lesion is invisible in the imaging modality

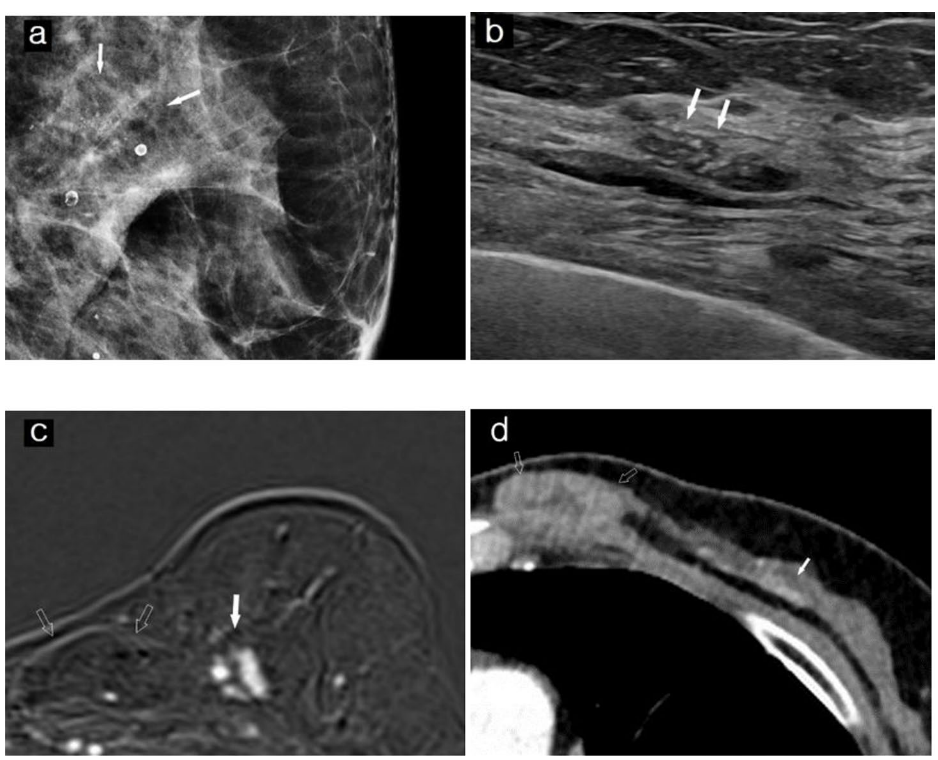


**Fig. 4** Surveillance image. A 57-year-old woman underwent breast-conserving surgery (BCS) with acellular dermal matrix (ACM) in the left breast. The patient refused adjuvant chemotherapy and radiotherapy, and recurrence was detected after 6 months. (**a**) Mammography showing grouped amorphous and pleomorphic microcalcifications (white arrow) adjacent to the BCS scar. (**b**) Ultrasonography showing ill-defined heterogeneous hypoechoic parenchymal lesions with hyperechoic dots representing calcifications (white arrow) in the upper inner quadrant of the left breast. An ultrasound-guided core needle biopsy was performed. (**c**) A subtracted 2-min sequence of magnetic resonance imaging shows non-mass-like enhancement of the lesion (white arrow) adjacent to the ADM pocket (empty arrows). (**d**) Chest computed tomography shows a non-mass-like enhancement of the lesion (white arrow) adjacent to the ADM pocket (empty arrows)

## Conclusions

The insertion of ADM after BCS is a safe and effective method for addressing volume defects in breast reconstruction, even though there is a slight reduction in ADM volume over time. However, further research is needed to assess the long-term impact of this volume reduction on aesthetic outcomes. To achieve this, large prospective studies focused on cosmetic evaluations and extended follow-up periods are essential.

### Abbreviations

| | |
|---|---|
| ADM | Acellular dermal matrix |
| BCS | Breast-conserving surgery |
| CT | Computed tomography |
| JP | Jackson–Pratt |
| MRI | Magnetic resonance imaging |
| US | Ultrasound |

## Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12893-025-02821-z.

Supplementary Material 1

Supplementary Material 2

### Acknowledgements

Not applicable.

### Author contributions

Conceptualization, Methodology: JAK, JSK, MBFormal Analysis: JAK, JSK, MBInvestigation: all authorsWriting– Original Draft: JAK, MBWriting– Review & Editing: JHB, BKK.

### Funding

None.

### Data availability

No datasets were generated or analysed during the current study.

## Declarations

### Ethics approval and consent to participate

The study protocol was approved by the Institutional Review Board of the Ulsan University Hospital (IRB number: 2023-01-003-001). The requirement for written informed consent from each patient was waived owing to the retrospective design of the study by the Institutional Review Board of the Ulsan University Hospital (IRB number 2023-01-003-001). Nevertheless, all patients signed the informed consent form for insertion of ADM preoperatively. All the experiments were performed in accordance with relevant guidelines and regulations (e.g., the Declaration of Helsinki).

### Consent for publication

Not Applicable.

### Competing interests

The authors declare no competing interests.

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## Publisher's note