Safety and Effectiveness of Acellular Dermal Matrix in Breast-Conserving Surgery for Breast Cancer: A Single-Institution Study

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Purpose: As breast-conserving surgery (BCS) has become the most common type of breast surgery, oncoplastic BCS has developed in response to improve cosmetic outcomes. Acellular dermal matrix (ADM) has been used as an adjunct to enhance cosmetic outcomes in partial breast reconstruction. This study aimed to evaluate postoperative complications, cosmetic satisfaction, and oncologic safety over a short-term follow-up period.

Methods: This retrospective study included 26 patients who underwent BCS at Myongji Hospital between April 2019 and April 2021. All procedures were performed by three surgeons. We reviewed demographic data, histologic grades, tumor-node-metastasis stages, treatment modalities, and survival data based on patient medical records.

Results: Of the 26 total patients, 5 developed seromas, which was the most common complication, and one patient experienced red breast syndrome. The incidence of complications per surgeon was less than 25%. The mean satisfaction score for the cosmetic outcome on a 10-point scale was 7.6 (± 2.1) as scored by patients and 8.8 (± 0.9) as scored by surgeons. Responses regarding cosmetic satisfaction revealed no significant differences among surgeons (p = 0.444). Of the 26 patients, four were lost to follow-up, and the mean follow-up period was 35.2 months. Two patients experienced recurrence, both of whom had regional recurrence with no local recurrence.

Conclusion: ADM replacement is a favorable alternative to oncoplastic BCS, in terms of the ease of surgical procedures, minimal complications, and low rates of local recurrence.

Key Words: Acellular dermal matrix, Breast conserving surgery, Breast neoplasm, Breast reconstruction

INTRODUCTION

The incidence of breast cancer continues to increase, making it the most common cancer among Korean women. According to statistics from the Korean Breast Cancer Society, the number of patients who have undergone breast-conserving surgery (BCS) has continued to increase since 2016, with 68.6% of patients diagnosed with breast cancer undergoing BCS in 2019 [1]. Where BCS is the most common type of surgery, oncoplastic BCS has developed in response to improve cosmetic outcomes [2]. The primary indication for oncoplastic BCS is a large tumor size in patients with small breasts. Oncoplastic BCS can be categorized into volume displacement and volume replacement techniques. For women with small breasts, volume displacement of the breast alone may lead to significant deformity. Volume replacement is the most suitable treatment method for patients with small sized breasts [3]. An acellular dermal matrix (ADM), derived from cadaveric skin using proprietary processing technology, provides the biochemical and structural components of the extracellular matrix and promotes tissue regeneration [4,5]. The safe integration of ADMs into host tissues, attributed to their low antigenicity, avoids issues such as resorption, contracture, and encapsulation [6]. Recently, ADMs have been used as an adjunct to enhance cosmetic outcomes in partial breast reconstruction [7].

Some studies have reported low postoperative ADM-related complications and high cosmetic satisfaction [8-10]. However, there is still inadequate evidence supporting the oncological safety of ADM and defining the associated postoperative complications.

This study aimed to evaluate postoperative complications, cosmetic satisfaction, and oncologic safety of ADM-based oncoplastic BCS among different surgeons within a single institution over a short-term follow-up period.

METHODS

Patients

This retrospective study included 26 patients who underwent BCS
with ADM at Myongji Hospital between April 2019 and April 2021. BCS with ADM was performed in patients who had > 10% of the total breast volume removed and required level 1 or higher oncoplastic BCS. Level 1 oncoplastic BCS was performed when < 20% of the breast volume was excised.

The follow-up period lasted until December 2023. Four of 26 patients were lost to follow-up. We reviewed patient medical records for demographic data, histologic grades, tumor-node-metastasis stages, treatment modalities, complications, and disease-free survival data. All patients underwent physical examination, mammography, breast ultrasonography, and magnetic resonance imaging. Most patients also underwent chest and abdominopelvic computed tomography or whole-body bone scans to evaluate distant metastases. During the follow-up period, imaging studies were conducted to discriminate between distant metastases, as in the preoperative imaging. Postoperative adjuvant hormone therapy, chemotherapy, and radiation therapy (RT) were administered to patients according to the current guidelines.

Disease-free survival was measured from the date of surgery to the date of any recurrence, last follow-up, or death, as recorded in the Statistics Korea records.

Patients were followed up with at one-month postoperatively to assess short-term complications such as infection, seroma, hematoma, red breast syndrome (RBS), and cosmetic satisfaction. Cosmetic satisfaction was assessed on a 10-point scale using a questionnaire: Scores of 0–4 were classified as dissatisfied, 5–6 as neutral, 7–8 as satisfied, and 9–10 as strongly satisfied.

Type of ADM

In this study, the crosslinked human ADM (Megaderm®, L&C Bio, Seoul, Korea) was derived from donated human skin in United States (US) tissue banks following the guidelines of the American Association of Tissue Banks and the US Food and Drug Administration. After removing epidermal and dermal cells from fresh human cadaver skin, electron beam irradiation was applied to the remaining acellular dermal layer to remove viruses, bacteria, and spores. The product was a 5 × 6 cm square plate with a thickness of 3–5 mm (Figure 1). Three different breast surgeons participated in each surgery.

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Figure 1. Acellular dermal matrix (Megaderm®).

Figure 2. Acellular dermal matrix (ADM) replacement. In the procedure of applying breast-conserving surgery using ADM. (A) We removed the tumor from the lesion located at the 3 o’clock of left breast using a circumareolar incision and removed it from the bottom to the top using an energy device. (B) We then applied Megaderm® over the tumor defect site.
Method of ADM replacement technique
The surgical method used for ADM replacement is shown in Figure 2. If simple primary suturing of the breast parenchyma was difficult or if filling of the surgical site was required after BCS, the ADM was inserted into the subcutaneous area of the tumor resection site.

Statistical analysis
Differences in clinicopathological characteristics between groups were assessed using the chi-square test, Fisher’s exact test, or Student’s t-test, as appropriate. Summary statistics are presented as numbers (%) for categorical variables. Analyses were performed using R (v4.3.2, R Development Core Team, Vienna, Austria; http://www.R-project.org/). Statistical significance was set at $p < 0.05$.

Ethics
This study adhered to the ethical tenets of the Declaration of Helsinki and was approved by the Institutional Review Board of Myongji Hospital (IRB no. 2023-12-029). The requirement for informed consent was waived due to the low risk posed by this study.

RESULTS

Patient characteristics
A total of 26 patients were included in the analysis. The clinical characteristics of the patients are summarized in Table 1. The median age was 49.9 years, and the mean body mass index (BMI) was 23.8 kg/m², with no smoking patients. Invasive ductal carcinoma, the predominant histological type of breast cancer, is hormone receptor-positive and human epidermal growth factor receptor-2-negative, and accounted for 65.4% of cases. Four patients were lost to postoperative follow-up, resulting in the completion of a follow-up period of 22 patients until December 2023. The mean follow-up period was 35.2 months, during which three patients were confirmed to have experienced recurrence.

Postoperative complications
A comparison of postoperative complications among the different surgeons is shown in Table 2. Complications were observed within the first 30 days postoperatively.

All procedures were performed by three surgeons, and no signifi-
cant differences in complications were observed ($p = 0.248$). Of the 26 total patients, five patients developed seromas, and one patient experienced RBS. Among the six patients with complications, none were smokers and one patient had diabetes mellitus (DM). The incidence of complications per surgeon was < 25%.

Cosmetic satisfaction in patients and surgeons

The mean satisfaction score for the cosmetic outcome on a 10-point scale was 7.6 (± 2.1) as scored by patients and 8.8 (± 0.9) as scored by surgeons (Table 1). Responses regarding cosmetic satisfaction revealed no significant differences among the surgeons ($p = 0.444$) (Table 3). Images of a patient who underwent follow-up imaging 6 and 12 months after surgery are presented in Figures 3 and 4, respectively. These images show minimal volume defects after surgery.

### DISCUSSION

Complications reported with ADM implantation techniques include skin necrosis, seroma, hematoma, infection, and RBS [11]. The
risk factors for complications include a history of DM, obesity, and smoking. RT is a potential contributing factor [12,13].

In this study, we addressed seroma and RBS complications. We defined seroma as aspiration of ≥ 30 cc of fluid. RBS was defined as the development of localized erythema in a predictable pattern on the breast skin over an ADM without systemic infection such as fever, swelling, or tenderness on palpation. Several hypotheses exist regarding the cause of RBS; however, one possibility is a type IV delayed hypersensitivity reaction. We treated the patient with RBS by applying a steroid ointment until the erythema had subsided.

In the present study, the most common complication was seroma, as reported in other studies. However, there was no need for reoperation because of infection. Despite all patients undergoing RT, the incidence of complications did not exceed that reported in previous studies [14,15]. As indicated by our results, none of the patients had a smoking history, and the mean BMI was 23.8 ± 3.3 kg/m². Only one patient with complications had DM.

ADM was initially used for skin replacement in burn injuries, abdominal wall repair, and other procedures. It was first introduced in breast surgery to correct problems, such as implant rippling, symmastia, and soft tissue defects [16]. The use of ADM is straightforward and simple, leading to the assumption that there are no complications based on the proficiency of surgeons employing ADM [17,18]. It is a simple, safe, and easily learned defect augmentation surgery method to insert a sheet-type ADM between the skin and breast tissues during BCS. We dissected the superficial fascia of the mammary gland to preserve adequate subcutaneous thickness, ensuring sufficient coverage of the ADM. Additionally, we determined the appropriate reconstructive volumes and meticulously calibrated the space for the human ADM to be used as a volume replacement. However, this procedure can be difficult for surgeons [7,19]. Interestingly, our findings are consistent with this assumption because we did not observe any noticeable variation in complication rates among the surgeons. Additionally, there was no statistically significant difference in cosmetic satisfaction related to surgeon experience. Consequently, the learning curve required to use the ADM in the volume replacement procedure appears
to be minimal.

Few studies have investigated local recurrence after ADM replacement, with only one study reporting a local recurrence rate of 2.5% at a mean follow-up of 22.8 months [20]. By contrast, our investigation specifically examined the local recurrence rate in patients who underwent ADM replacement. Although the follow-up duration was relatively short (mean follow-up, 35.2 months), we did not observe any local recurrence specifically related to the same breast. However, regional recurrence and distant metastases were reported in our study. Although the limited number of cases in this pilot study precluded robust statistical analysis, we found that ADM insertion did not have a significant impact on local recurrence rates.

This study has some limitations. These findings were based on a small number of patients and should be interpreted with caution. Further research with a larger sample size and longer-term follow-up is necessary to validate these findings.

ADM replacement is a viable alternative to oncoplastic surgery. Our observations indicated minimal complications, notably RBS and seroma formation, with no instances of local recurrence. When >10% of the mammary gland is excised, and oncoplastic BCS becomes imperative, employing a sheet-type ADM has emerged as a safe and convenient method to address breast defects.

CONFLICT OF INTEREST

The authors declare that they have no competing interests.

REFERENCES


