Volume replacement in tumor plastic surgery and breast-conserving surgery using 3D grid and strip-shaped acellular dermal matrix: Two case reports

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Abstract. The present study was driven by the scarcity of suitable materials for mending partial breast defects and the imperative considerations of safety and durability. The current study presents findings from two female patients, aged 59 and 40, who underwent breast cancer treatment. Patient 1 underwent a mastectomy with a sentinel lymph node biopsy, while patient 2 underwent a partial mastectomy with axillary lymph node dissection. Core needle biopsy confirmed invasive ductal carcinoma in both cases. Breast ultrasound revealed hypoechoic lesions with smooth edges. The reconstruction of the breast defect employed an acellular dermal matrix, and the safety and cosmetic outcomes for each patient were analyzed. At 3 months post-radiotherapy, neither patient experienced significant complications. The preservation of breast contour and volume was satisfactory, with no postoperative tumor recurrences detected. In summary, utilizing an acellular dermal matrix with a three-dimensional grid design for partial breast defect reconstruction offers a viable alternative that aligns with oncological safety standards and provides good cosmetic results.

Introduction

Breast-conserving surgery (BCS) is widely accepted as an oncologically secure procedure and has become one of the predominant breast cancer surgical techniques (1). The evolution of oncoplastic surgery alongside BCS aims to reduce breast deformities post-surgery (2). Nonetheless, significant tissue removal during BCS can result in a noticeable depression, which is particularly pronounced in patients with smaller breasts (3). Recent research indicates that utilizing acellular dermal matrices (ADM) for breast reconstruction presents a promising solution to address these challenges (4).

In breast reconstruction, ADMs are predominantly utilized as a covering for implants (5). Their use has expanded recently, particularly in implant-based reconstructions following nipple-sparing and skin-sparing mastectomies (6,7). The application methods for ADM in breast surgery are well-established, with a solid safety profile that has been corroborated by the literature (8,9). Yet, instances of ADM being employed in BCS reconstructions remain infrequently documented.

The present study documented the impact of two methods of manipulating ADM on the restoration of breast volume during conserving surgeries. By varying the dimensions and configuration of the ADM, superior cosmetic results were achieved with a concomitant decrease in complication rates compared with traditional breast-conserving surgery. Furthermore, the study suggested the viability of a specific type of ADM material. Utilizing ADM with a honeycomb-like, open three-dimensional structure was presented as a viable alternative for addressing the limitations associated with breast-conserving surgery.

Methods. In the present study, two patients with breast cancer were treated at Tangshan People's Hospital (Tangshan, China). The admission dates for Patient 1 was July 2023 and for Patient 2 was August 2023. The patients underwent lumpectomies to excise the cancerous tissue, ensuring clean surgical margins, and then received reconstruction with ADM (National Medical Products Administration reg. no. 20223130801) (Beijing Ruijian High-tech Biotechnology Co., Ltd.). Neither of the individuals had pre-existing conditions such as diabetes or any connective tissue disorders. Both were released from the hospital 2 days post-operation. The patients were monitored every 24 h for 72 h after surgery for post-surgical complications, which included the development of seromas, infections and pain levels. Cosmetic outcomes

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Abbreviations: ADM, acellular dermal matrices; BCS, Breast-conservation surgery; MRI, magnetic resonance imaging; HR, hormone receptor; HER2, human epidermal growth factor receptor 2

Key words: acellular dermal matrix, breast-conservation surgery, three-dimensional grid structure

were self-rated by the patients using a 4-point scale in a survey taken immediately after the operation and again 3 months post-radiotherapy (10,11). The present study also reviewed the clinicopathological data. For follow-up assessments, ultrasonography and breast magnetic resonance imaging (MRI) were employed.

Surgical techniques. Prior to the surgical procedure, a radiologist used an ultrasound to guide the placement of a needle, pinpointing the primary tumor and any adjacent areas of concern, which were then delineated on the surface of the breast. The patients were positioned on their backs with their arms outstretched. Local anesthetic was administered, followed by the insertion of a needle to re-confirm the locations of any questionable lesions through the use of intraoperative ultrasound, ensuring accurate tumor localization. The surgical team then proceeded with the standard lumpectomy, maintaining clear margins of 1 to 2 cm. Additionally, for patient 1, sentinel lymph node sampling was conducted; for patient 2, axillary lymph node dissection was conducted.

During the operation, the present study conducted an immediate frozen section analysis of tissue from the resection cavity to verify the margins were free of cancer cells. Once clear margins were established, the surgical team proceeded with securing hemostasis and rinsing the wound. The ADM was then prepared for implantation; it was first hydrated in saline solution, after which multiple 5-mm incisions were created with a no. 11 scalpel blade. Gentamicin sulfate (Thermo Fisher Scientific, Inc.) was prepared in sterile 0.9% saline at a concentration of 3.2 μ/ml. The ADM, now perforated, was immersed in the antibiotic solution for 5 to 10 min. Following this, the ADM was thoroughly rinsed with saline once more before being placed into the surgical defect.

Case report

The characteristics of both patients are summarized in Table I.

Patient 1. A female patient aged 59 received a diagnosis of invasive ductal carcinoma in her right breast, confirmed via core needle biopsy. She had a BMI of 20.12 kg/m^2. Ultrasonographic examination of the breast revealed an atypical mass with ductal enlargement, measuring roughly 0.81 cm in its largest dimension (Fig. 1A). Subsequent breast MRI depicted an enhancing lesion consistent with ductal architecture (Fig. 1B).

The patient was treated with a segmental mastectomy and a sentinel node biopsy. The excised breast tissue weighed 13.4 g. Prepared ADM was fashioned into strips measuring 1 cm by 5 cm (Fig. 1C). Once a frozen section confirmed the absence of residual cancer in the margins of the excised tissue, the breast defect was filled with the prepared ADM strips. To secure the ADM in place and prevent displacement, each corner of the ADM strip was sutured using 3-0 silk sutures within the defect area (Fig. 1D). This process may take an extra 10 min compared with traditional breast-conserving surgery. Closure of the surgical site involved a two-tiered approach, with the deeper glandular tissue and the superficial skin sutured separately (12). Drainage of excess fluid was managed by a surgically placed closed drain. The incision was meticulously sutured in two layers with resorbable 3-0 and 4-0 monofilament sutures (Johnson & Johnson). Post-surgery, an elastic bandage was applied, ensuring it was not too tight to prevent compression of the reconstructed breast. Pain assessment using a visual analog scale (13) indicated an average postoperative pain level at three different times during the patient's hospitalization. The patient was released from the hospital on the third postoperative day. The final pathology report described a 0.8 cm invasive ductal carcinoma with a hormone receptor-positive profile. At 3 months post-radiotherapy, the integrity of the ADM was confirmed via ultrasound and breast MRI imaging (Fig. 1E-F). Tumor HE staining and immunohistochemical staining are shown in Fig. 2 (Department of Pathology, Tangshan People's Hospital, Tangshan City, Hebei Province, China). The patient assessed the cosmetic outcome as excellent, referencing a 4-point scale (14,15), both 3 days after surgery and 3 months post-radiotherapy (Fig. 3A-I).

Patient 2. A 40-year-old female patient received a diagnosis of invasive ductal carcinoma in her left breast following a core needle biopsy. Her BMI was recorded at 27.3 kg/m^2. Ultrasound imaging revealed a complex mass with associated smaller nodules, measuring ~2.5 cm (Fig. 4A). Additionally, a contrast-enhanced breast MRI identified an irregularly shaped mass in the upper outer quadrant of the breast (Fig. 4B).

The patient underwent partial mastectomy and axillary lymph node dissection. The excised breast tissue weighed 21 g. A pattern of perforations, spaced 0.5 cm apart, was created on the ADM material (Fig. 4C). This ADM was then fashioned into a three-dimensional, grid-like construct, measuring 1x5 cm (Fig. 4C). The corners of this ADM grid were securely sutured into the surgical cavity using 3-0 white silk stitches to ensure the material remained in place (Fig. 4C). This process may take an extra 10 min compared with traditional breast-conserving surgery. Closure of the surgical site was achieved through a two-layer technique, encompassing both glandular and superficial dermal tissues (12). A closed suction drain was placed to facilitate fluid removal. The incision was meticulously closed in two layers with interrupted, dissolvable 3-0 and 4-0 monofilament sutures (Johnson & Johnson). Postoperatively, the site was dressed with a gently applied elastic bandage to support the breast structure. Pain levels, monitored by a visual analog scale, indicated an average pain score of 4 during the inpatient recovery. The patient was discharged at 3 days post-operation. Pathological analysis confirmed a 2.0 cm invasive ductal carcinoma, HR-positive, HER2-positive as the final diagnosis.

At 3 months post-radiotherapy, the three-dimensional framework of the ADM had established itself as a solid internal scaffold, with no significant structural alterations evident on ultrasound and MRI scans of the breast (Fig. 4E-F). Tumor HE staining and immunohistochemical staining are presented in Fig. 5 (Department of Pathology, Tangshan People's Hospital, Tangshan City, Hebei Province, China.). The patient assessed her surgical outcome as favorable initially, and post-radiotherapy, she reported an excellent aesthetic result, utilizing a standardized four-point evaluative scale (Fig. 6A-I).

Table I. Clinicopathological profiles of patients with breast cancer who were treated with lumpectomy followed by reconstruction using acellular dermal matrix.

Parameter	Patient 1	Patient 2
Sex/age, years	F/59	F/40
Type of tumor	Invasive ductal carcinoma	Invasive ductal carcinoma
Multifocality	No	No
Removed breast tissue, g	13.4	21.0
Pathological tumor size, cm	0.8	2.0
Resected tissue volume, ml[a]	14	22
Hormone receptor status	Positive	Positive
Her2 gene expression	Negative	Positive
Resection margin	Negative	Negative
No. of metastatic/total removed axillary lymph nodes	0/4	11/20
TNM stage	pT1N0M0	pT1N3M0
Adjuvant chemotherapy	No	Yes
Adjuvant radiotherapy	Yes	Yes
Adjuvant hormone therapy	Yes	Yes
Postoperative complication	No	No
Postoperative pain score based on a visual analog scale	3	4
A satisfactory degree of cosmesis after surgery	Excellent	Excellent
A satisfactory degree of cosmesis after radiotherapy	Excellent	Excellent

[a]The graduated cylinder method was used for measurement.

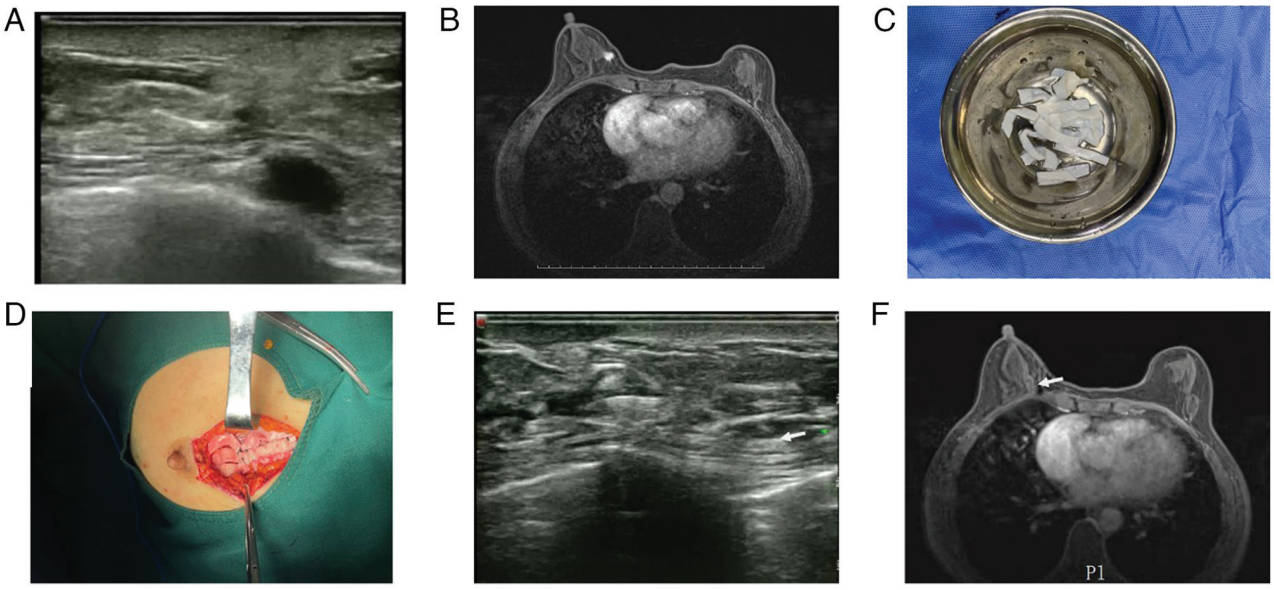

Figure 1. Preoperative and postoperative findings of patient 1. Patient 1 was diagnosed with an invasive ductal carcinoma in her right breast. (A) Ultrasonography revealed a 0.81 cm irregular mass. (B) MRI revealed a 0.9 cm abnormally enhanced signal. (C) The washed ADM was cut into 1x5 cm strips. (D) Surgical process was performed using striped ADM. The four corners of the ADM strip were fixed in the defect cavity with white silk 3-0 sutures to prevent ADM from migrating. Finally, the incision was closed using a double-layer skin closure technique. At 3 months post-radiotherapy (E) ultrasonography and (F) MRI views (ADM indicated using arrows). MRI, Magnetic resonance imaging; ADM, acellular dermal matrices.

Discussion

Initially investigated for the treatment of extensive skin repair after severe burns (16), the application of ADM has since expanded across multiple surgical disciplines. It now serves as a protective layer when healing wounds, tendons, bones, cartilage and nerves (12,17), and plays a role in the reconstruction of various bodily structures (18). In contemporary practices, ADM is utilized in nipple-sparing and skin-sparing mastectomies for implant coverage, where the stability of the treatment

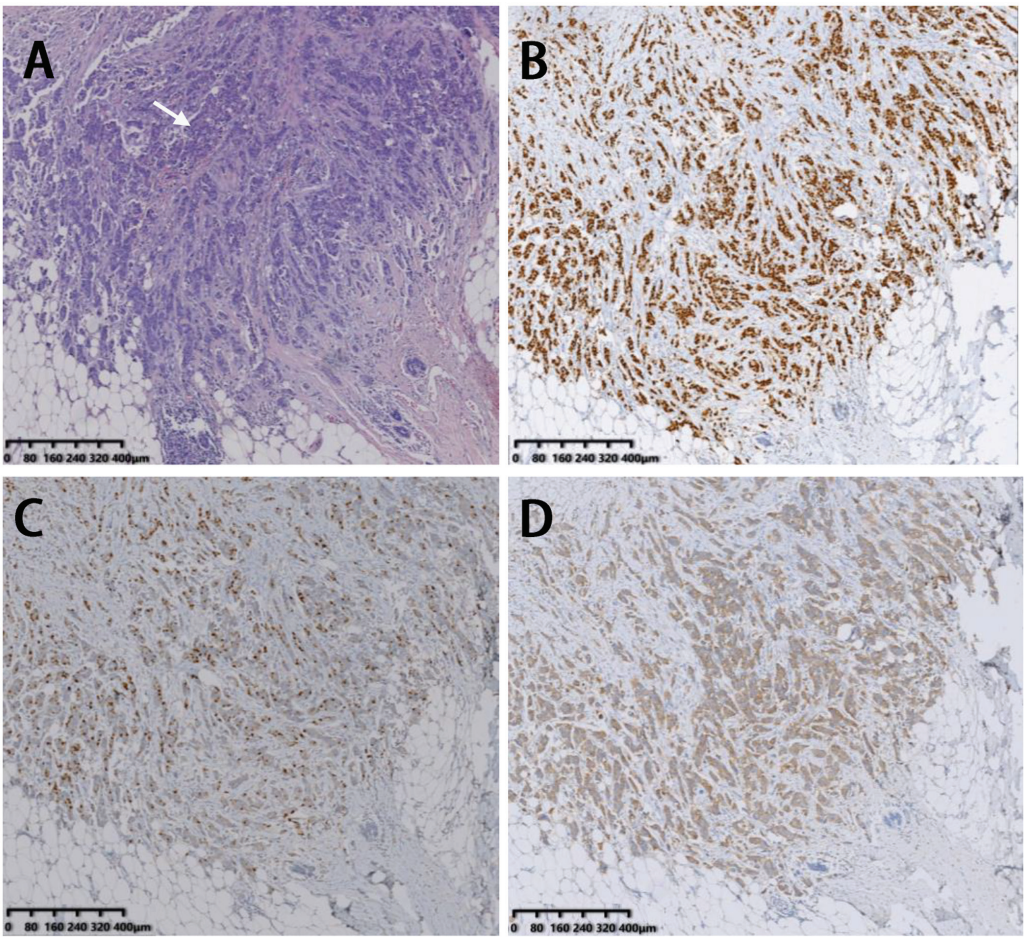

Figure 2. Tumor HE staining and immunohistochemical staining. (A) HE staining of tumor tissue. White arrow indicates breast cancer tissue. (B) Positive immunostaining for ER. (C) Positive immunostaining for PR. (D) Negative immunostaining for HER2. Magnification, x40. HE, hematoxylin and eosin; ER, estrogen receptor; PR, progesterone receptor; HER2, human epidermal growth factor receptor 2.

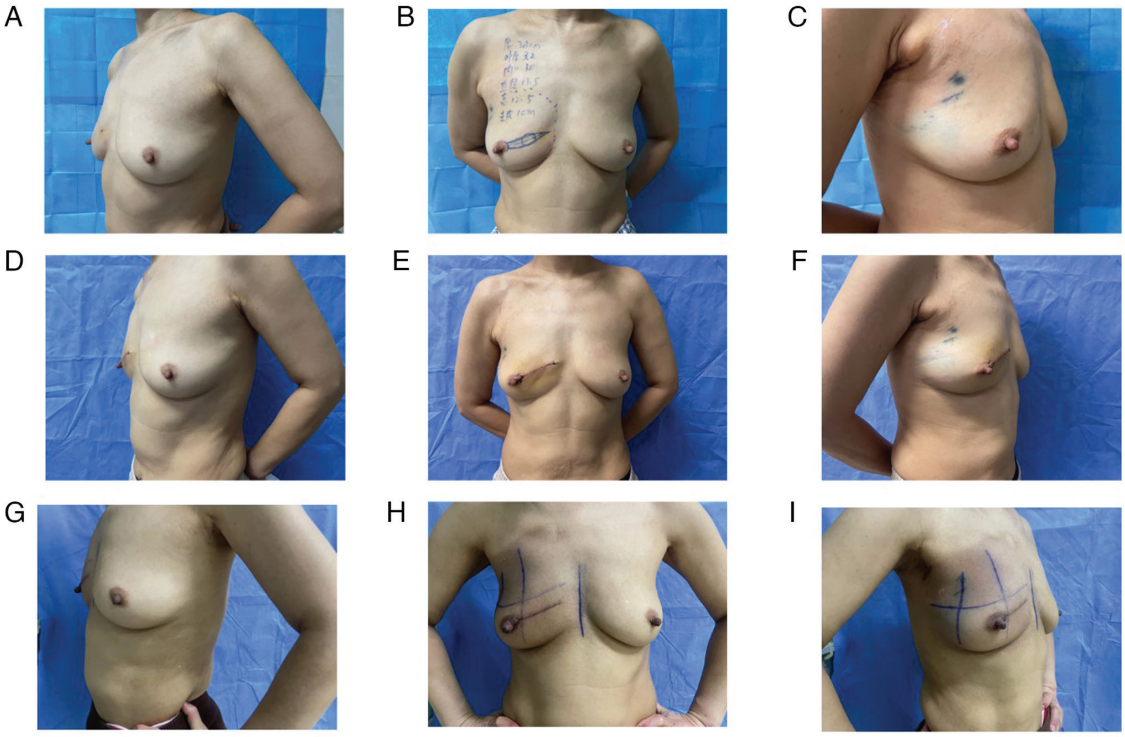

Figure 3. Results of acellular dermal matrix augmentation technique after partial mastectomy. (A-C) Preoperative patient images. (D-F) Patient images 3 days after surgery. (G-I) Patient images at 3 months post-radiotherapy.

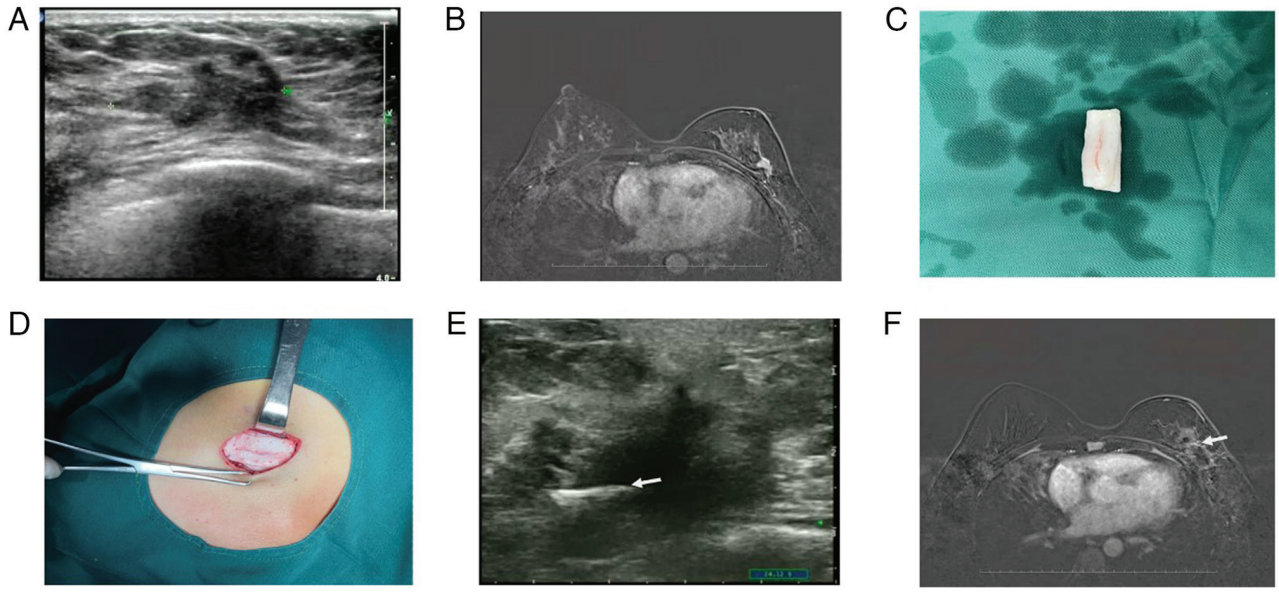

Figure 4. Preoperative and postoperative findings of patient 2. Patient 2 was diagnosed with an invasive ductal carcinoma in her left breast. (A) Ultrasonography revealed a 2.5 cm irregular mass. (B) MRI revealed a 1.5 cm abnormally enhanced signal. (C) A hole was made every 0.5 cm on the ADM patch. (D) The ADM patch was folded into a three-dimensional grid-like structure of 1x5 cm. The four corners of the ADM three-dimensional grid structure were fixed in the defect cavity with white silk 3-0 sutures to prevent ADM from migrating. At 3 months post-radiotherapy (E) Ultrasonography and (F) MRI views (ADM indicated with arrows). MRI, Magnetic resonance imaging.

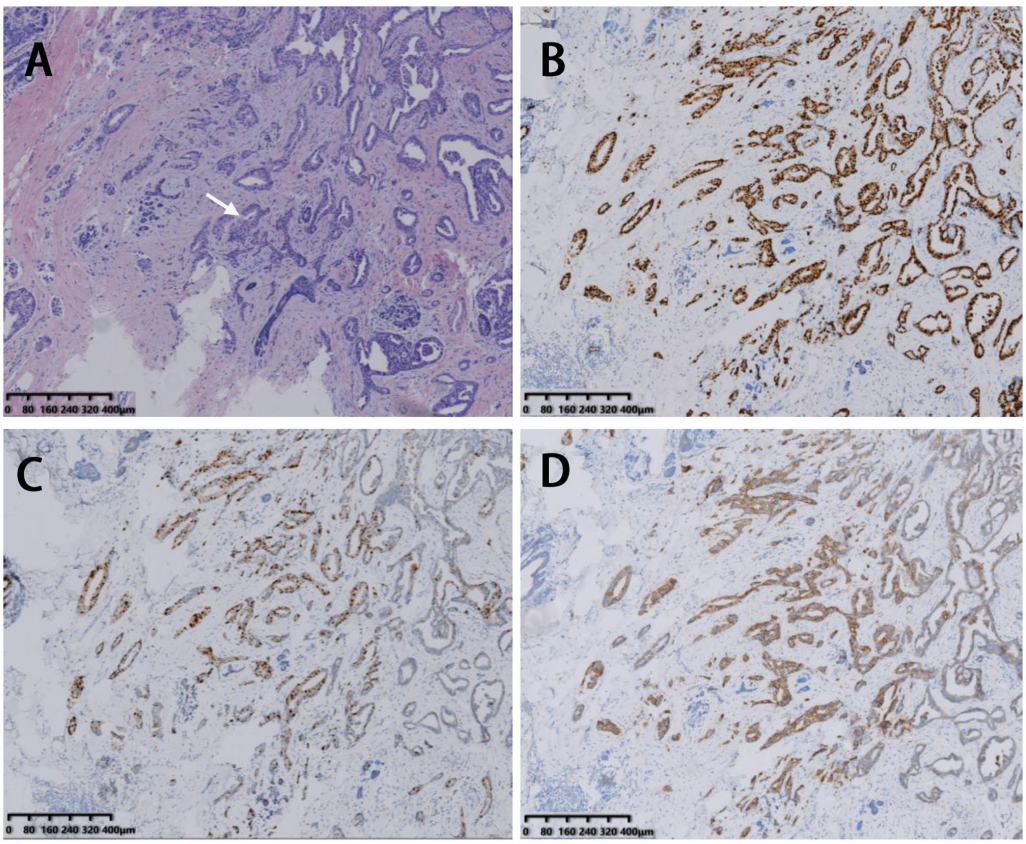

Figure 5. Tumor HE staining and immunohistochemical staining (magnification, x40). (A) HE staining of tumor tissue. White arrow: breast cancer tissue. (B) Positive immunostaining for ER. (C) Positive immunostaining for PR. (D) Positive immunostaining for HER2. HE, hematoxylin and eosin; ER, estrogen receptor; PR, progesterone receptor; HER2, human epidermal growth factor receptor 2.

has been established. Despite these advancements, its use in reconstructive BCS remains relatively underexplored (19,20).

Lee *et al* (10) have explored the synergy of ADM and ORC in reconstructing partial breast defects. Their findings suggest

Figure 6. Results of acellular dermal matrix augmentation technique after partial mastectomy. (A-C) Preoperative patient images. (D-F) Patient images 3 days after surgery. (G-I) Patient images at 3 months post-radiotherapy.

that this combination is a viable method with promising aesthetic results for patients with breast cancer. However, they noted that while ADM provides structural support, the absorption of ORC over time can lead to breast shape alterations (10). Additionally, a study from Korea examined the comparative outcomes of using sheet-like vs. pellet-like ADM forms in post-breast conservation surgery. The results underscore the effectiveness of ADM in promptly restoring breast contour post-surgery. It has been observed that the pellet form more closely mimics the pre-surgical appearance of the breasts, although it may pose challenges in terms of stability and movement within the breast (4).

The present study presents two distinct techniques of utilizing ADM for volumetric reconstruction in breast-conservation surgery. For patient 1, the present study segmented the ADM into slender strips instead of using a single large piece. This strategy not only accommodates the specific contours of the surgical cavity but also promotes re-epithelialization, neovascularization and fibroblast migration. After a year, the patient demonstrated excellent recovery and maintained breast contour post-radiotherapy without any complications. In patient 2, the present study enhanced the structure of ADM by perforating and folding it to create a three-dimensional matrix. This approach appeared to provide improved structural support and aesthetic outcomes as compared with the strip method, particularly in surgeries where similar volumes of tissue are excised. These findings lead us to consider the potential of manufacturing ADM pre-formed into a three-dimensional grid for breast-conservation reconstructive surgery (Fig. 7). The exploration of this area is currently in the clinical trial phase. Since this hypothesis is still in the clinical phase, data collection is not yet complete, so the data cannot be disclosed. However, based on the existing research, we found that regardless of the method used to apply ADM for breast defect augmentation, no apparent signs of foreign objects were observed in the imaging examination at 3 months after

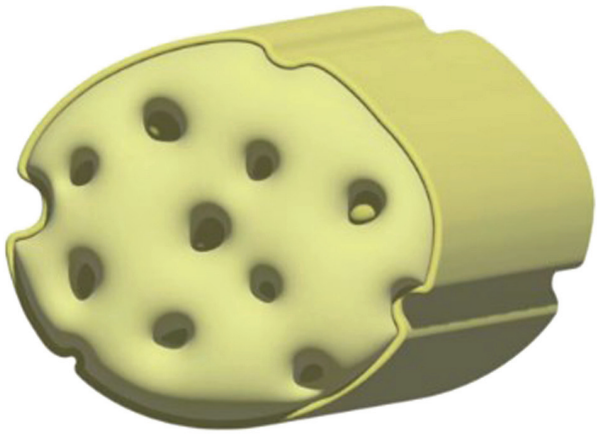

Figure 7. Three-dimensional mesh structure acellular dermal matrix. The traditional sheet-like two-dimensional AMD is made into a three-dimensional structure. The structure is honeycomb-shaped to facilitate the formation of a vascular network.

radiotherapy. This indicates that ADM material can integrate well with the human body, ensuring safety.

The present study envisages a transformation of the traditional sheet-like ADM into a lattice of filamentous fibers, reconstituted into a honeycomb-like three-dimensional scaffold with strategically placed perforations, as depicted in Fig. 7. This re-engineered scaffold is non-degradable and biocompatible, designed to avoid breast contour changes over time due to structural failure. The honeycomb design serves a dual purpose: It minimizes ADM volume and residual foreign material within the cavity, and it enhances the infusion and integration of interstitial fluids, encouraging the development of a fibrovascular matrix. Moreover, the modified spatial configuration of the ADM not only augments its pliability, offering a more natural feel to the touch, but also allows surgeons to tailor the scaffold to the unique contours of the residual breast cavity, optimizing the aesthetic outcome. Our clinical observations suggest that this innovative three-dimensional ADM structure can significantly enhance cosmetic outcomes for patients undergoing breast-conservation surgery while reducing postoperative complications.

In conclusion, the techniques explored in the present study facilitated the preservation of breast tissue even when excising larger tumors or addressing multifocal lesions within the same quadrant. The current research research indicated that employing ADM for such procedures is oncologically sound, with no elevation in the risk of breast cancer recurrence observed. Additionally, the postoperative breast contour was well-preserved, and no significant complications were encountered. In modern medicine, utilizing ADM fashioned into a honeycomb-like, loosely structured three-dimensional scaffold was a viable approach, yielding superior cosmetic outcomes for breast cancer defect repair compared with traditional breast-conserving surgery.

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Availability of data and materials

The data generated in the present study may be requested from the corresponding author.

Authors' contributions

YW and SW acquired the data. JH, XL and JM analyzed and interpreted the data.JM and YW confirm the authenticity of all the raw data. JH and YW designed the methodology. JH and YW conceived and designed the study. JM, XL and SW supervised. YW wrote the original draft. JW reviewed and edited the paper. All authors have read and approved the final manuscript.

Ethics approval and consent to participate

This investigation received approval from the ethics committee at Tangshan People's Hospital (Tangshan, China; approval no. 2022-005-001). Prior to enrollment, written informed consent was secured from both patients, adhering to the ethical principles outlined in the Declaration of Helsinki.

Patient consent for publication

Written informed consent was obtained from the patients for publication of this case report and any accompanying images.

Competing interests

The authors declare that they have no competing interests.

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