The use of meshes and matrices in breast reconstruction

ABSTRACT

Breast cancer is the most common cancer diagnosed in the UK (Cancer Research UK, 2018). Breast reconstruction following mastectomy can be performed with prosthetic devices or autologous tissue. In the UK implant-based breast reconstruction following mastectomy is the most common type of breast reconstruction, estimated to account for 70% of the reconstructive caseload in the UK. Since 2001 there has been a considerable increase in the number of prosthetic reconstructions performed with the use of mesh or matrix to augment the reconstructive pocket. This article introduces the main types of mesh and matrix used in implant-based breast reconstruction, reconstructive techniques and reviews the benefits and complications associated with their use.

Breast cancer is the most common cancer diagnosed in the UK and is predicted to rise by 2% in incidence between 2014 and 2035 (Cancer Research UK, 2018). One in eight women will be diagnosed during their lifetime (Cancer Research UK, 2018). Breast cancer surgery involves either breast-conserving surgery (wide local excision) or mastectomy, depending upon individual patient factors and tumour staging. For women undergoing mastectomy there are three options:

1. Simple mastectomy
2. Mastectomy with immediate reconstruction (skin sparing or nipple sparing)
3. Mastectomy with delayed reconstruction.

Breast reconstruction can be performed with prosthetic devices (implant or expander) or autologous tissue (pedicled and free tissue flaps) (Rolph et al, 2016). In the UK implant-based breast reconstruction following mastectomy is the most common type of breast reconstruction, with immediate breast reconstruction being offered routinely (Jeevan et al, 2014). Implant-based breast reconstruction is estimated to account for 70% of the reconstructive caseload in the UK (Mylvaganam et al, 2017).

Traditionally, implant-based breast reconstruction was offered as a two-stage procedure involving skin-sparing mastectomy with placement of an expander submuscularly (subpectoral or total muscle coverage) beneath the mastectomy flap. The expander would be inflated to the desired volume via a tunnelled subcutaneous port over a number of postoperative outpatient visits. A second stage procedure would then be performed to remove the expander and port and exchange them for a permanent fixed volume implant. The submuscular pocket enabled soft tissue coverage of the expander, but limited the volume of the reconstructed breast as a result of the dimensions of the pocket created with the patient's tissue. The introduction of mesh into prosthetic breast reconstruction in 2001 enabled the surgeon to augment the size of the reconstructive pocket by releasing the pectoral muscle from the chest wall and using the mesh for lower pole coverage (Breuing and Warren, 2005; Salzberg, 2006). This article introduces the main types of mesh and matrix used in implant-based breast reconstruction, and discusses the benefits and complications associated with their use.

Miss Rachel Rolph, Honorary Research Fellow, Department of Plastic and Reconstructive Surgery, Guys and St Thomas' NHS Foundation Trust, London SE1 7EH

Professor Jian Farhadi, Consultant Plastic Surgeon, Department of Plastic and Reconstructive Surgery, Guys and St Thomas' NHS Foundation Trust, London

Correspondence to: Miss R Rolph (r.rolph@nhs.net)

What are the meshes and matrices used in breast reconstruction?

The terms mesh and matrix in breast reconstruction refer to the composition of the material used in the manufacture of the product. A product derived from biological sources, e.g. peritoneum or dermis, is termed 'acellular (dermal) matrix or matrices' whereas synthetic material is referred to as 'mesh or meshes' (*Table 1*).

The use of acellular dermal matrices in prosthetic breast reconstruction began with the publication of two papers by Breuing and Warren (2005) and Salzberg (2006). The authors described the use of a biological mesh in implant-based reconstruction to augment the inferolateral subpectoral pocket, allowing direct to implant reconstruction without the need for expander placement. This innovative technique allowed more women to be considered for direct to implant immediate breast reconstruction.

Since then, the popularity of mesh and matrix augmented immediate prosthetic breast reconstructions has increased dramatically. For example, from 2007 to 2014 in the UK, 21 862 women underwent immediate reconstruction with direct to implant reconstruction increasing from 30% to 54% (Mennie et al, 2017). In parallel with the shift in surgical practice, a variety of meshes and matrices has become available for use and new products continue to emerge in this field (*Table 1*). The various devices differ in physical properties and composition. Some patients may prefer to avoid devices made from animal or human tissue and therefore their wishes must be considered in preoperative planning.

Table 1. Meshes and matrices in breast reconstruction		
Biological matrices	Cadaveric human dermis	AlloDerm, AlloMax, FlexHD, Dermacell, DermaMatrix
	Porcine dermis	Strattice, Cellis, Braxon, Artia, Permacol, Protexa
	Porcine peritoneum	Sebbin
	Bovine fetal dermis	SurgiMend PRS
	Bovine pericardium	Veritas
Synthetic meshes	Absorbable polymers	Vicryl polyglactin 910, TIGR, GalaFORM 3D
	Non-absorbable titanium-coated polymers	TiLOOP, TiO_2 mesh

In the iBRA (implant breast reconstruction evaluation) UK survey of breast and plastic surgical practice, 75% of immediate implant breast reconstructions were performed using acellular dermal matrix *vs* 24% using synthetic mesh (Mylvaganam et al, 2017). The choice of mesh or matrix to be used is mainly determined by the individual surgeon's preference and patient choice. It has been demonstrated that implant-based breast reconstruction with mesh has a significant learning curve and therefore surgeons have a tendency to use the product with which they have most experience (Colwell et al, 2011).

There have been two randomized controlled trials comparing different meshes in breast reconstruction. Mendenhall et al (2015) reported a head-to-head comparison of cadaveric dermal matrices DermaMatrix and AlloDerm in breast reconstruction. This single centre randomized trial of two cadaveric dermal matrices in implant-based breast reconstruction (n=199) demonstrated no significant difference in complication rates between the different products (Mendenhall et al, 2015). Gschwantler-Kaulich et al (2016) reported results from a prospective randomized multi-centre pilot study comparing Protexa, a porcine dermal matrix, with TiLOOP Bra, a titanium-coated synthetic mesh (Gschwantler-Kaulich et al, 2016) in immediate implant-based breast reconstruction. Forty-eight patients participated in the study, which means that this pilot is underpowered to demonstrate significant differences in benefits and complication rates between the two products. Further level 1 evidence is required to inform surgeons about complication rates for the various products available for use in this area.

How does the surgeon use the mesh in breast reconstruction?

A number of techniques are in current practice, which are variations on the principles set out in the original papers by Breuing and Warren (2005) and Salzberg (2006).

Submuscular technique

The most commonly reported technique in the literature is the partial submuscular technique. The skin-sparing mastectomy is completed and the breast skin flap is assessed for tissue perfusion and viability. In patients at high risk of skin flap necrosis, the surgeon may decide to place an expander to reduce the pressure on the skin and position the device submuscularly for additional tissue coverage of the implant (Colwell et al, 2011). Partial submuscular breast reconstruction involves releasing the pectoralis major from its attachments to the chest wall. The subpectoral plane is developed to the second rib superiorly and to the level of the nipple medially. Meshes or matrices are then sutured medially from the inferomedial border of the pectoralis major to the medial border of the inframammary fold. The mesh or matrix is then sutured from the inferior border of the muscle to the chest wall fascia at the level of the inframammary fold to increase the inferior aspect of the subpectoral pocket for lower pole projection. Laterally the device is sutured to define the breast border and prevent migration of the implant. The mesh provides a lower pole hammock and inferolateral coverage for the implant (Scheflan and Colwell, 2014).

Prepectoral (subcutaneous) technique

As implant-based breast reconstruction with mesh became an established practice, refinements of the technique were being developed. From 2011 onwards surgeons have re-introduced the concept of prepectoral implant placement – an established practice in breast augmentation – to the breast reconstruction field. The pectoralis muscle is left intact on the chest wall, with the implant being covered solely by mesh or matrix and the mastectomy skin envelope (Cheng et al, 2013; Schmitz et al, 2013; Casella et al, 2014; Reitsamer and Peintinger, 2015). The implant is wrapped completely within the mesh or matrix before being placed underneath the skin flap or alternatively the mesh or matrix is sutured to the pectoralis fascia to provide anterior coverage to the implant only.

The technique has quickly been adopted as an alternative approach to implant-based breast reconstruction (Vidya and Iqbal, 2017; Bonomi et al, 2018). Proponents of the muscle-sparing technique emphasize that by leaving the pectoralis major intact, patients experience reduced postoperative pain and shorter operative times. Animation deformity of the breast in subpectoral reconstructions is a recognized complication of the submuscular approach. On contraction of the pectoralis muscle, the breast implant is displaced supero-laterally with visible distortion to the reconstructed breast (Vidya et al, 2018). Up to

KEY POINTS

- Matrices and meshes in prosthetic breast reconstruction are derived from biological and synthetic sources.
- Their use in implant-based breast reconstruction has increased exponentially and has quickly become standard practice in the majority of reconstructive centres.
- Meshes and matrices can be used to augment the inferolateral aspect of a subpectoral reconstruction or as implant coverage in prepectoral reconstructions.
- Their use has enabled surgeons to offer direct-to-implant reconstruction following mastectomy, avoiding secondary procedures associated with two-stage expander reconstruction.
- Level 1 evidence is limited on the use of meshes and matrices in breast reconstruction, with conclusions drawn from cohort studies. Therefore data regarding their effect on patient outcomes are limited.

75% of women with subpectoral implant-based breast reconstruction report animation deformity and may result in patient dissatisfaction necessitating revision surgery (Nigro and Blanchet, 2017). Animation deformity has not been reported following prepectoral implant-based breast reconstruction.

A number of cohort studies have reported positive early results with prepectoral implant-based breast reconstruction with comparable complication rates to subpectoral implant reconstruction (Bettinger et al, 2017; Nahabedian and Cocilovo, 2017; Chatterjee et al, 2018). However, studies are limited by heterogeneity of design, retrospective nature, small numbers and short-term results which prevents any conclusions being drawn regarding any differences between the two surgical techniques. Authors report previous breast radiation, adjuvant chemotherapy, smoking and high body mass index to be relative contraindications to this technique as a result of higher observed complication rates (Nahabedian and Cocilovo, 2017).

What are the benefits and complications associated with mesh or matrix used in breast reconstruction?

The introduction of meshes and matrices in implant-based breast reconstruction has enabled the surgeon to increase the reconstructive volume placed in immediate direct-to-implant reconstructions by extending the subpectoral pocket in the submuscular approach. This is particularly useful in patients with larger ptotic breasts where there is a discrepancy between the size of the subpectoral pocket and the overlying skin envelope (Madsen et al, 2015). The use of mesh or matrix can also help to shape and define the reconstructive pocket following skin-sparing mastectomy. During mastectomy the breast footprint may become ill-defined, particularly if dissection exceeds the inframammary fold or lateral border of the breast into the axilla. The mesh can be sutured and shaped in a way that the reconstructive surgeon can redefine the breast shape, particularly at its inferior, medial and lateral borders, to create a pleasing aesthetic result with maintained lower pole projection (Ibrahim et al, 2015). The mesh or matrix may also prevent implant rotation or migration by fixing the implant into position within the reconstructive pocket. Studies have reported that the coverage of the implant reduces the capsular contracture rate with adjuvant radiotherapy and improves cosmesis, although the data to support this conclusion are limited (Salzberg et al, 2011; Potter et al, 2015). Complications associated with implant-based breast reconstruction include infection, seroma, haematoma, skin flap necrosis (nipple necrosis), wound dehiscence, extrusion of the implant and loss of the implant.

A number of systematic reviews has been published evaluating the data on complication rates in implant-based breast reconstruction with and without mesh or matrix (Potter et al, 2015; Hallberg et al, 2018). Unfortunately, the certainty of evidence for overall complication rates and potential benefits of mesh in implant-based breast reconstruction is low, because of a paucity of high quality level 1 evidence in this field. Heterogeneity persists between study design and outcome measures reported in published randomized controlled trials. No studies have reported data on cancer recurrence or health-related quality of life in implant-based breast reconstruction with and without mesh or matrix, which remains an important outcome to be addressed.

Conclusions

The use of meshes and matrices in implant-based breast reconstruction is a relatively recent additional technique in immediate one- and two-stage breast reconstruction following mastectomy. Clinicians should be aware that the majority of prosthetic breast reconstructions are now performed with matrix or mesh. A variety of biological and synthetic products is available for use and surgical techniques are rapidly evolving including the shift from subpectoral to prepectoral implant placement. Well-designed randomized controlled trials are required to investigate further the benefits, complication rates and impact on patient outcomes associated with their use. **BJHM**

Conflict of interest: none.

Bettinger LN, Waters LM, Reese SW, Kutner SE, Jacobs DI. Comparative study of prepectoral and subpectoral expander-based breast reconstruction and Clavien IIIb score outcomes. Plast Reconstr Surg Glob Open. 2017 Jul 26;5(7):e1433. https://doi.org/10.1097/GOX.0000000000001433

Bonomi S, Sala L, Cortinovis U. Prepectoral breast reconstruction. Plast Reconstr Surg. 2018 May 21. https://doi.org/10.1097/PRS.0000000000004560

Breuing KH, Warren SM. Immediate bilateral breast reconstruction with implants and inferolateral AlloDerm slings. Ann Plast Surg. 2005 Sep;55(3):232–239. https://doi.org/10.1097/01.sap.0000168527.52472.3c

Cancer Research UK. 2018. Breast cancer incidence (invasive). (accessed 17 July 2018) https://www.cancerresearchuk.org/health-professional/cancer-statistics/statistics-by-cancer-type/breast-cancer#heading-Zero

Casella D, Bernini M, Bencini L et al. TiLoop® Bra mesh used for immediate breast reconstruction: comparison of retropectoral and

subcutaneous implant placement in a prospective single-institution series. Eur J Plast Surg. 2014;37(11):599–604. https://doi.org/10.1007/s00238-014-1001-1
Chatterjee A, Nahabedian MY, Gabriel A et al. Early assessment of post-surgical outcomes with pre-pectoral breast reconstruction: A literature review and meta-analysis. J Surg Oncol. 2018 May;117(6):1119–1130. https://doi.org/10.1002/jso.24938
Cheng A, Lakhiani C, Saint-Cyr M. Treatment of capsular contracture using complete implant coverage by acellular dermal matrix: a novel technique. Plast Reconstr Surg. 2013 Sep;132(3):519–529. https://doi.org/10.1097/PRS.0b013e31829acc1e
Colwell AS, Damjanovic B, Zahedi B, Medford-Davis L, Hertl C, Austen WG Jr. Retrospective review of 331 consecutive immediate single-stage implant reconstructions with acellular dermal matrix: indications, complications, trends, and costs. Plast Reconstr Surg. 2011 Dec;128(6):1170–1178. https://doi.org/10.1097/PRS.0b013e318230c2f6
Gschwantler-Kaulich D, Schrenk P, Bjelic-Radisic V et al. Mesh versus acellular dermal matrix in immediate implant-based breast reconstruction - A prospective randomized trial. Eur J Surg Oncol. 2016 May;42(5):665–671. https://doi.org/10.1016/j.ejso.2016.02.007
Hallberg H, Rafnsdottir S, Selvaggi G et al. Benefits and risks with acellular dermal matrix (ADM) and mesh support in immediate breast reconstruction: a systematic review and meta-analysis. J Plast Surg Hand Surg. 2018 Jun;52(3):130–147. https://doi.org/10.1080/2000656X.2017.1419141
Ibrahim AM, Koolen PG, Ganor O et al. Does acellular dermal matrix really improve aesthetic outcome in tissue expander/implant-based breast reconstruction? Aesthetic Plast Surg. 2015 Jun;39(3):359–368. https://doi.org/10.1007/s00266-015-0484-x
Jeevan R, Cromwell DA, Browne JP et al. Findings of a national comparative audit of mastectomy and breast reconstruction surgery in England. J Plast Reconstr Aesthet Surg. 2014 Oct;67(10):1333–1344. https://doi.org/10.1016/j.bjps.2014.04.022
Madsen RJ Jr, Chim J, Ang B, Fisher O, Hansen J. Variance in the origin of the pectoralis major muscle: implications for implant-based breast reconstruction. Ann Plast Surg. 2015 Jan;74(1):111–113. https://doi.org/10.1097/SAP.0b013e3182858881
Mendenhall SD, Anderson LA, Ying J, Boucher KM, Liu T, Neumayer LA, Agarwal JP. The BREASTrial: stage I. Outcomes from the time of tissue expander and acellular dermal matrix placement to definitive reconstruction. Plast Reconstr Surg. 2015 Jan;135(1):29e–42e. https://doi.org/10.1097/PRS.0000000000000758
Mennie JC, Mohanna PN, O'Donoghue JM, Rainsbury R, Cromwell DA. National trends in immediate and delayed post-mastectomy reconstruction procedures in England: A seven-year population-based cohort study. Eur J Surg Oncol. 2017 Jan;43(1):52–61. https://doi.org/10.1016/j.ejso.2016.09.019
Mylvaganam S, Conroy E, Williamson PR et al; iBRA Steering Group; Breast Reconstruction Research Collaborative. Variation in the provision and practice of implant-based breast reconstruction in the UK: results from the iBRA national practice questionnaire. Breast. 2017 Oct;35:182–190. https://doi.org/10.1016/j.breast.2017.07.016
Nahabedian MY, Cocilovo C. Two-stage prosthetic breast reconstruction: a comparison between prepectoral and partial subpectoral techniques. Plast Reconstr Surg. 2017 Dec;140(6S Prepectoral Breast Reconstruction):22S-30S. https://doi.org/10.1097/PRS.0000000000004047
Nigro LC, Blanchet NP. Animation deformity in postmastectomy implant-based reconstruction. Plast Reconstr Surg Glob Open. 2017 Jul 24;5(7):e1407. https://doi.org/10.1097/GOX.0000000000001407
Potter S, Browning D, Savović J, Holcombe C, Blazeby JM. Systematic review and critical appraisal of the impact of acellular dermal matrix use on the outcomes of implant-based breast reconstruction. Br J Surg. 2015 Aug;102(9):1010–1025. https://doi.org/10.1002/bjs.9804
Reitsamer R, Peintinger F. Prepectoral implant placement and complete coverage with porcine acellular dermal matrix: a new technique for direct-to-implant breast reconstruction after nipple-sparing mastectomy. J Plast Reconstr Aesthet Surg. 2015 Feb;68(2):162–167. https://doi.org/10.1016/j.bjps.2014.10.012
Rolph R, Mehta S, Farhadi J. Breast reconstruction: options post-mastectomy. Br J Hosp Med (Lond). 2016 Jun;77(6):334–342. https://doi.org/10.12968/hmed.2016.77.6.334
Salzberg CA. Nonexpansive immediate breast reconstruction using human acellular tissue matrix graft (AlloDerm). Ann Plast Surg. 2006 Jul;57(1):1–5. https://doi.org/10.1097/01.sap.0000214873.13102.9f
Salzberg CA, Ashikari AY, Koch RM, Chabner-Thompson E. An 8-year experience of direct-to-implant immediate breast reconstruction using human acellular dermal matrix (AlloDerm). Plast Reconstr Surg. 2011 Feb;127(2):514–524. https://doi.org/10.1097/PRS.0b013e318200a961
Scheflan M, Colwell AS. Tissue reinforcement in implant-based breast reconstruction. Plast Reconstr Surg Glob Open. 2014 Sep 8;2(8):e192. https://doi.org/10.1097/GOX.0000000000000140
Schmitz M, Bertram M, Kneser U, Keller AK, Horch RE. Experimental total wrapping of breast implants with acellular dermal matrix: a preventive tool against capsular contracture in breast surgery? J Plast Reconstr Aesthet Surg. 2013 Oct;66(10):1382–1389. https://doi.org/10.1016/j.bjps.2013.05.020
Vidya R, Iqbal FM. A guide to prepectoral breast reconstruction: a new dimension to implant-based breast reconstruction. Clin Breast Cancer. 2017 Jul;17(4):266–271. https://doi.org/10.1016/j.clbc.2016.11.009
Vidya R, Tafazal H, Salem F, Iqbal FM, Sircar T. Management based on grading of animation deformity following implant-based subpectoral breast reconstruction. Arch Plast Surg. 2018 Mar;45(2):185–190. https://doi.org/10.5999/aps.2017.01242