

Internal bra: a unifying solution for reconstructive and aesthetic breast surgery issues

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ABSTRACT

The utility of the internal bra for breast support, reconstruction, and in revision breast surgery has been recognized and various materials have been introduced for this application. As clinical experience has grown and new products have been developed, the roles of these materials are becoming better defined. This paper reviews the use of the internal bra concept to date.

Key words:

Internal bra; acellular dermal matrix; alloderm; strattice; SERI surgical scaffold; GalaFLEX mesh; revision breast surgery; mastopexy

INTRODUCTION

Factors leading to revision breast implant surgery include capsular contracture, implant malposition, palpability, and animation deformity with subpectoral placement. These issues often occur in combination,^[1] for example lower or lateral fold malposition with rippling or animation deformity with fold malposition. Reoperation rates for breast implant procedures are high, and even higher for previous revision surgery.^[2] A comprehensive approach is needed if these numbers are to be improved.

There are certain commonalities underlying the issues

leading to revision breast surgery. Implant malposition and rippling are manifestations of thin tissue coverage, which can be thought of as periprosthetic atrophy. This in turn may relate to overly large implants, improper biodimensional planning, and saline implants as a result of fluid wave action. Aging, pregnancies, weight loss, and prior surgeries may contribute to weakening of the ligamentous support and soft tissue envelope of the breast. In combination, these patient-related and implant-related factors may multiply the severity of periprosthetic atrophy. Autologous material such as capsule flaps^[3,4] and fat grafting can be useful adjuncts in

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Table 1. Criteria for the ideal internal bra material

Criteria
No interference with mammography
Biocompatible
Bio-inductive: template for long-term host tissue replacement
Maintains strength until host tissue replacement
Handling characteristics: easy to template and suture
Easily stored and ready-to-use
Available in a range of sizes
Affordable
Natural feel

recreating a stable breast implant pocket, but are not always capable of providing a comprehensive solution.

Recognition of the potential benefit of non-autologous internal breast support was initially constrained by the lack of suitable materials [Table 1]. Most of the products were developed for hernia repair and general soft tissue support rather than for breast procedures specifically. These materials can be classified as first generation (nonresorbable synthetics), second generation (acellular dermal matrix), and third generation (slowly resorbable textiles) [Table 2]. The developing role of these products will be reviewed.

FIRST GENERATION INTERNAL BRA MATERIALS

The use of polypropylene mesh with reduction mammoplasty was reported in 1981,^[5] and more recently a three-dimensional pre-shaped polyester mesh was developed.^[6] Because Wise pattern/inverted T patterns rely on the skin envelope to shape the breasts, by offloading the support and shaping of the breast from the skin to the mesh, the role of short scar techniques expanded. Góes^[7] originally proposed the use of resorbable mesh with periareolar mastopexy but noted longer lasting results with a mixed mesh (40% polyester, 60% polyglactin). More recently, a titanium-coated mesh (TiLOOP® Bra) has been introduced in Europe.^[8] Nevertheless, concerns about biofilms and a permanent foreign body in the subcutaneous layer of the breast have limited the adoption of this approach.^[9] For these same reasons, non-resorbable meshes have had limited use in revision breast surgery although they helped establish proof of concept for the idea of an internal bra.

SECOND GENERATION MATERIALS

Duncan^[10] first reported the use of human-derived acellular

Table 2. Internal bra materials

First generation	Second generation	Third generation
Mixed mesh (polyester/polyglactin)	Human ADM	Silk fibroin mesh
Polypropylene mesh	• Alloderm	• SERI Scaffold
Polyester three-dimensional cone	• Dermamatrix	P4HB mesh
Titanium-coated polypropylene (TiLOOP® Bra)	• FlexHD	• GalaFLEX
	• AlloMax	• Phasix
	Porcine ADM	Mixed
	• Stratrice	• TIGR® (Fast resorbing copolymer of lactide, glycolide and trimethylene carbonate; slow-resorbing copolymer of lactide and trimethylene carbonate)
	• Permacol	

ADM: acellular dermal matrix

dermal matrix (ADM) in revision breast surgery for correction of implant rippling. This was later expanded to include a variety of implant-related problems, with the common denominator being inadequate soft tissue support and/or coverage.^[11] Histologic analysis demonstrated integration and transformation into host tissue, with follow-up as long as 12 years.^[12] The ability of these materials to replace deficient or weakened tissue led to their widespread adoption in breast reconstruction and revision breast surgery and became the standard for many years.^[13] Host tissue response and long-term integration may be affected by decellularization and sterilization methods which can alter the architecture of the matrix.^[14]

ADM's have proven valuable in the setting of revision breast implant surgery, for both reconstructive and cosmetic cases.^[15-17] In primary reconstruction, they may allow for more rapid tissue expansion and higher initial fill volumes, though prospective studies on this are limited and inconsistent. Selection of an adequately sized piece is important.^[18] Direct-to-implant immediate reconstruction with skin-sparing mastectomy relies on the use of ADM's to offload the weight of the implant from the skin envelope and control pocket shape.^[19]

Further experience with ADM's revealed their resistance to radiation, of particular benefit to reconstruction patients.^[20] Another observation was a much lower than expected incidence of capsular contracture in reconstruction patients,^[21] leading to the use of ADM's in revision breast surgery for established capsular contracture.^[22,23] In this application, the material may afford protection against recurrent contracture, possibly related to altered inflammatory aspects of capsule formation.^[24] Importantly, ADM's serve to replace tissue support and implant coverage after capsulectomy. This ability to provide instant, predictable, and durable tissue thickness remains a primary advantage of ADM's. Porcine-derived ADM's, designed to offer a non-human source alternative, have found utility in this application. In general, porcine ADM's have more consistent thickness and less stretch than human-derived ADM's.

The use of ADM's has been mostly limited to the periprosthetic layer for creation of a stable pocket for implants, as a pectoral extension for post-mastectomy breast reconstruction and in revision aesthetic breast implant surgery. Use of an ADM internal bra in reduction

Table 3. Comparison of Internal bra materials

	Advantages	Disadvantages
First generation Polypropylene mesh; Mixed mesh	Durable; Affordable; Variety of sizes and shapes	Foreign body may be subject to biofilms/ infection/exposure; Possible interference with mammograms
Second generation Human-derived ADM	Potentially very long lasting; Elastic (facilitates tissue expansion); Extensive clinical record	Expensive; Potential for seromas; Need for long-term drains; Red breast syndrome; Limited sizes
Porcine-derived ADM	Potentially very long lasting; Inelastic; 1:1 correction for revision surgery; Instant thickness	Same as human-derived
Third generation SERI Scaffold, P4HB mesh	More affordable than ADM's; Variety of shapes and sizes; Slowly resorbing with induction of replacement by host tissue; Open weave may facilitate fluid egress and mesh integration	Limited clinical data for breast surgery

ADM: acellular dermal matrix

mammoplasty has been proposed,^[25] but the large pieces required can make it expensive. In the case of reconstruction, the concept of an internal bra is logical as the breast mound is entirely comprised of the implant; in the case of a breast augmentation, the concept is more limited because it supports the implant but not breast tissue unless placed in a more superficial layer. This would require placement in a subcutaneous layer, encompassing both implant and breast. ADM's are not generally suitable for this application without extensive meshing as with skin grafts.

Disadvantages of ADM's include cost,^[26] concerns about animal or cadaveric sourcing, the need for long-term suction drains,^[27] and complications such as red breast syndrome and seromas.^[28,29] Placement of fenestrations may ameliorate these issues to a degree.^[30] Another limitation is the inability to form an adherent capsule on textured implants, which may be desired in some cases to prevent rotation of form-stable implants.

THIRD GENERATION

As ADM's helped to propel the concept of an internal bra, the need for more versatile materials became evident. Slowly resorbing materials which induce formation of a strong and durable host tissue layer would have the versatility of permanent meshes and the biocompatibility of ADM's. SERI[®] surgical scaffold (Allergan, Inc.), comprised of purified fibroin silk, and meshes based on poly-4-hydroxybutyrate (GalaFLEX[®], Tepha Medical Devices) are the leading products in this category.

Silk-based scaffolds have been explored in various reconstructive surgery applications because of their potential to induce a host response characterized by site-specific tissue replacement.^[31] Raw silk consists primarily of

two proteins: fibroin, comprised of fibers with high tensile strength, and sericin, a glue-like substance which coats the fibroin strands but provokes an inflammatory response as an implant. Removal of the sericin component yields a biocompatible material that can be woven or knitted into various configurations.^[32] Experimentally, implantation is quickly followed by fibroblast migration, adherence, and proliferation.^[33] Early iterations of implantable fibroin-based scaffolds included anterior cruciate ligament^[34] and abdominal wall repair.^[35] Silk scaffolds seeded with specific cell lines or growth factors is an active area of research in tissue engineering.^[36]

SERI[®] surgical scaffold is a knitted multifilament implantable material derived from the cocoons of the silkworm *Bombyx mori*. It is easily cut without unraveling and suitable for a variety of applications in breast reconstruction, revision breast surgery, and some cases primary aesthetic breast surgery such as augmentation-mastopexy.^[37] In an ovine model of two-stage breast reconstruction, SERI scaffold demonstrated maintenance of burst strength greater than host fascia through 12 months, with histologic evidence of scaffold resorption and replacement by new tissue.^[38] Interim one-year data from an ongoing clinical trial of two-stage breast reconstruction shows low complication rates and high patient satisfaction.^[39] Early results from a European trial with SERI in direct-to-implant reconstruction after skin-sparing mastectomy showed good aesthetic outcomes and acceptable complication profile.^[40]

Poly-4-hydroxybutyrate is a bio-derived polymer produced by micro-organisms under specific conditions. P4HB is a monofilament used as a suture or knitted into a mesh, and is somewhat stiffer than SERI[®] scaffold. Clinical experience with P4HB meshes is extensive but only recently has it been applied to breast surgery.^[41] In a porcine model of abdominal

wall repair, PHASIX® knitted mesh (Tepha) demonstrated burst strength significantly greater than native tissue at all points up to one year.^[42] As with silk scaffolds, a variety of uses for constructs based on PHB have been explored, including heart valves.^[43] Clinical trial results for GalaFLEX® (P4HB mesh) in breast surgery have not yet been reported but a trial in mastopexy and reduction mammoplasty is ongoing.

A composite mesh comprised of fast-absorbing and slow-absorbing fibers has also been explored (TIGR® Matrix surgical mesh, Novus Scientific.) At an average follow-up of 16 months, a favorable complication rate was observed in a case series of breast reconstruction, revision implant surgery, and primary aesthetic procedures.^[44]

Because third generation meshes facilitate subcutaneous placement, mastopexy may be performed without parenchymal disruption or reliance on a tight skin envelope. For all internal bra materials, the ability to offload the weight of the breast during the transition from graft to host is critical. Quickly-resorbing materials lose support before host tissue can develop, so the ability of the material to induce or support ingrowth or replacement by host tissue is an important variable. In practice, it is important to take advantage of the internal bra concept by adapting the skin envelope of the breast to the shape created by the material and close incisions under minimal tension. This may minimize the potential for would breakdown and exposure of the material. Minimal tension closure may reduce the potential for hypertrophic scarring as well. The ability to shape the breast mound as a composite unit of implant and parenchyma by wrapping in a subcutaneous internal bra may prevent long-term problems of differential implant or breast ptosis.

DISCUSSION

By restoring support due to attenuated or weak tissues, revision surgery for combination problems may find a unifying solution with the internal bra. Despite the paucity of robust long-term data for newer materials, they are finding a role in clinical practice. Each has its own limitations and advantages [Table 3]. Although there are general characteristics that are desirable across the category, different applications require specific mesh attributes. In revision surgery, elasticity and expandability may be disadvantages while they are pluses for tissue expansion. Placement in the subcutaneous layer is necessary for mastopexy, but placement too superficially may result in unacceptable palpability or risk of exposure, while in a deeper layer, non-take may be a concern because of less vascularity. The consequences of non-take for second and third generation materials include exposure, infection, and possible need for removal of both the material and implant. As application-specific characteristics such as pore size, fiber size, monofilament vs. multifilament, degradation profiles, and textile engineering become better understood, these materials will be better optimized. The introduction of fixation devices and 3-dimensionally shaped constructs may broaden the appeal of the internal bra.

CONCLUSION

The concept of an implantable internal bra continues to evolve. Third generation biomaterials designed to act as templates that resorb and initiate tissue neogenesis address many of the issues posed by non-resorbable materials and acellular matrices, but have only recently become widely available and less is known about complication rates and best practices. As indications become better defined and clinical experience grows, the use of these materials appears poised to usher in a new generation of regenerative surgery.

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