Emerging Applications for Acellular Dermal Matrices in Mastopexy

Bradley P. Bengtson, MD[a,*], Richard A. Baxter, MD[b,c]

KEYWORDS

• Acellular dermal matrix • Mastopexy
• Periareolar mastopexy • Strattice™ • AlloDerm®
• Mesh mastopexy • ADM • Revision augmentation

Key Points

- Meshed acellular dermal matrix (ADM) as an internal bra may help prevent bottoming out and maintain upper pole fullness over the long term after mastopexy.
- Early experience shows a potentially useful application of ADM donut- or washer-shaped grafts in revision periareolar mastopexy.
- ADM grafts for periareolar mastopexy may prevent areolar widening and unfavorable scarring.
- Permanent suture and mesh materials for mastopexy support may be complicated by biofilms, infections, and other late-presenting problems not associated with ADMs.

Acellular dermal matrices (ADMs), originally developed for the treatment of burn patients, are now an important emerging technology in complex hernia repair, orthopedics, breast reconstruction and now revision aesthetic surgery of the breast. Their use in breast reconstruction and cosmetic breast revision was, in retrospect a fortuitous development. Although Level 1 evidence is lacking and is increasing, ADMs have unquestionably become helpful adjuncts for these applications. As techniques and best practices have developed, the array of uses expanded from revision surgery to primary implant-based reconstruction, and from simple capsule reinforcement to repair of fold malpositions and animation deformity. New applications continue to be explored, some of which are described in this article. However, these are in early stages of development and their long-term value remains to be demonstrated.

GENERAL CONSIDERATIONS IN MASTOPEXY

Although a popular procedure, mastopexy continues to be plagued by long-term loss of upper pole fullness

Disclosures: Dr Bengtson is a consultant for Allergan Medical and LifeCell Corporation/KCI; a lead investigator for Natrelle Style 410 cohesive gel implant studies: Core and Continued Access; an investigator for Allergan responsive gel and Mentor gel core and adjunct studies; and an Aesthetic Surgery Education and Research Foundation (ASERF) grant recipient for high resolution ultrasound research.
Dr Baxter is a consultant and speaker for LifeCell Corporation and Allergan Breast Aesthetics, and an investigator for Sientra, Inc.
[a] Bengtson Center for Aesthetics and Plastic Surgery, 555 MidTowne Street NE, Suite 110, Grand Rapids, MI 49503, USA
[b] Private Practice, Seattle, WA, USA
[c] Plastic Surgery Clinic, 6100 219th Street SW, Suite 290, Mountlake Terrace, WA 98043, USA
* Corresponding author.
E-mail address: drb@bengtsoncenter.com

Clin Plastic Surg 39 (2012) 159–166
doi:10.1016/j.cps.2012.02.006

despite early good results.[1] Mastopexy was initially conceived as a skin reshaping operation, with parenchyma adapting passively to the skin envelope.[2,3] Results with these techniques were generally satisfactory and they became the standard approach for several years. Mastopexy techniques are still described according to the cutaneous scar configuration.[4] However, the push to short scar techniques prompted a focus on parenchymal reshaping and less reliance on the skin envelope for support.[5] Nevertheless, these may also relapse over time, and more extensive parenchymal dissection and mobilization in an attempt to enhance projection and upper pole fullness is not always an optimal solution.

An internal bra composed of deepithelialized dermis has been proposed as a means of maintaining shape while limiting tension on the skin envelope. However, because of the surface area required, it is suitable primarily for cases of "remarkable hypertrophy or severe ptosis"[6] and has not become popular. Dermal bra procedures are generally limited to Wise pattern mastopexy, and are less appropriate for limited scar techniques.

Because of these difficulties in maintaining shape and projection, various mesh materials have been tried for additional support. Polypropylene mesh was used as early as 1981 with reduction mammaplasty.[7] With the introduction of short scar techniques, the concept of an internal mesh bra in the subcutaneous layer was developed. Absorbable mesh has been used, with the hope that a scar layer would form in the configuration of the mesh bra, but this technique did not produce long-lasting results with periareolar mastopexy.[8] In an attempt to maintain shape, a mixed mesh (40% polyester, 60% absorbable polyglactin) was used with reportedly better results, although long-term follow-up was not specified.[9] Preshaped polyester mesh has also been used with reported success.[10] Follow-up histology showed a mechanically strong but supple mesh with collagen ingrowth.[11] Despite the success reported by some, other reports have shown that a permanent foreign body in the subcutaneous layer of the breast may be subject to biofilm and infection.[12] These types of concerns about synthetic mesh in the breast have limited its adoption.

The use of autologous or cadaveric dermal slings for mastopexy mesh was reported by Colwell and Breuing[13] in a series of 10 patients, 5 in each category. The authors proposed an algorithm for selecting either autologous tissue or ADM based on the quantity and quality of skin available. Results were stable at 6 months to 3 years in this series, indicating that tissue-based mesh could provide an alternative to synthetic mesh and durable results (**Fig. 1**).

An acellular product, FortaPerm (Organogenesis, Canton, MA, USA), has also been used with periareolar mastopexy.[14] FortaPerm is a highly crosslinked and laminated material derived from porcine intestinal submucosa, and its primary application is in urology, where it has been used for pubovaginal slings.[15] It is believed to be slowly resorbed and replaced with a native collagen layer. For mastopexy support, the material is passed through a Zimmer mesher and the entire breast is wrapped. The ideal product would be noninflammatory and biocompatible, such as ADM, so it can be incorporated without loss of integrity.

PATIENT SELECTION FOR ADM FOR MASTOPEXY

Given the high cost of ADM materials, their use will likely become routine for primary mastopexy, despite the variability of long-term stability of shape and projection with standard techniques. However, for cases of recurrent ptosis or pseudoptosis, the use of a mesh bra provides an option. In the case of augmentation mastopexy with bottoming out, the use of ADM is well-established, so its use for mastopexy without implants represents an extension of the same

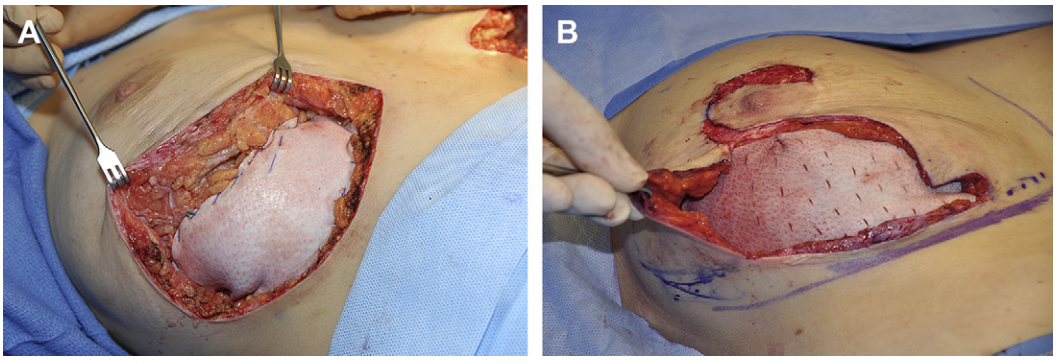

Fig. 1. (*A, B*) Dermal slings for mastopexy mesh.

concept. Patients who have experienced massive weight loss may have atrophic tissues despite an abundance of extra skin available for use as an autologous graft. In this sense, the same principle applies to patients receiving an implant and those with ptosis: replacing "like with like" through using a connective tissue matrix to reinforce weakened tissues that provide inadequate support. In addition, the cellular tissue requirements of an autogenous tissue are more demanding than those of the acellular dermal–collagen construct that ADMs provide, and also obviate the problems associated with thin, nonuniform pieces when trying to use the patient's own tissues.

TECHNICAL POINTS: MASTOPEXY HAMMOCK

Given the limited experience with ADM mesh for mastopexy support, technical considerations are still evolving. A primary concern is selection of the appropriate ADM material. In expander/implant reconstruction, human-derived ADM may be favored because of its potential to expand, but this may be a counterproductive property for ptosis repair. For that reason, porcine-derived materials such as Strattice™ (LifeCell Corporation, Branchburg, NJ, USA) may be preferable. These materials are relatively inelastic and used for abdominal wall repair and revision implant surgery. However, the ability of porcine-derived ADM to conform to a three-dimensional contour is limited for the same reason. A premeshed version may become available, but a series of incisions with a #15 blade can suffice to expand and modify the product to some degree (**Fig. 2**). Perforating may also improve the "take" of the material or minimize the risk of seroma formation in the subcutaneous plane, but too much may weaken it.

A critical decision in planning is the size and shape of the ADM. For a periareolar mastopexy, totally encasing the parenchymal mound in a cone of ADM may be required for optimal projection, as is done with synthetic and composite mesh materials using the Góes method. Most cases will probably only require a sling across the lower pole, analogous to a demi cup bra. Further experience will help refine the process for selecting the optimal size and orientation.

To provide fixation of the mesh at the boundaries of the breast mound, adequate undermining is required. Vigilance in attention to flap thickness is necessary because of the wider undermining. Fixation to chest wall is necessary unless the mesh is used only for shaping, but generally, setting the inframammary, medial, and lateral folds is helpful and necessary if a sling effect is desired. If possible, a cuff of the graft a few millimeters wide is splayed onto the chest wall and sutured with #00 polydioxanone or similar resorbable material. The anterior or superior edge may be sutured directly to the parenchyma or deepithelialized dermis. Sitting the patient upright to asses shape is critical before final tailoring and adjustments. Matching the internal bra to the skin envelope in the upright position avoids irregularities from redundancy and overresection leading to tension on the closure.

Periareolar Mastopexy

Periareolar mastopexy has a long history in breast surgery, dating back to the 1970s according to recent literature.[16–18] Since its inception, it has been associated with a wide variety of complications or at least issues that have made it less than ideal with surgeons mainly adding a vertical component or looking at other techniques. These issues were well reviewed by Spear and colleagues in 1990[19] and 2001.[20] As described, Góes has used the periareolar approach but also adds gland reshaping, and often uses internal mesh support to help hold the gland in position and remove periareolar tension. Hammond and colleagues[21] described an excellent and intriguing

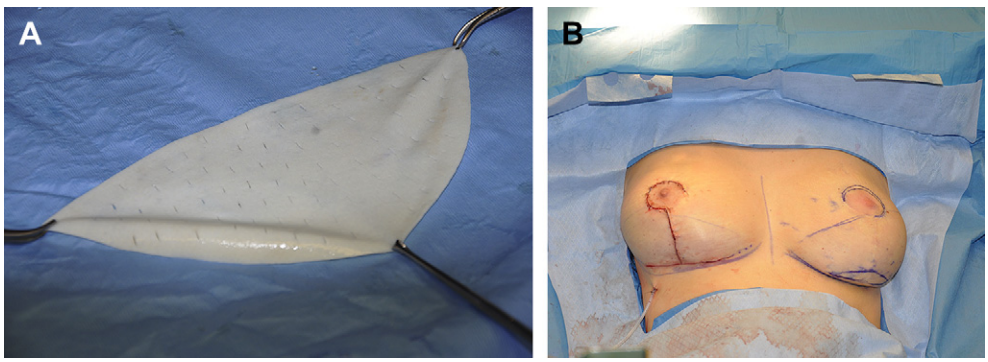

Fig. 2. Strattice™ porcine-derived ADM with multiple perforations from a #15 blade for use in mastopexy support.

technique of an interlocking polytetrafluoroethylene (Gore-Tex; W. L. Gore & Associates, Inc., Flagstaff, AZ, USA) suture that can maintain nice areolar shape but still has the potential for Biofilm, extrusion, and suture track infection. Secondary to these limitations, many surgeons, except in minimal nipple repositioning, have added a vertical component that helps limit the flattening from a periareolar mastopexy alone, unless some additional breast shaping is performed.

ADMs

Beginning with AlloDerm® in treating complex burn wounds and now extending into multiple uses and subspecialties, a multitude of ADMs are now being used in reconstructive breast surgery and a wide variety of ever-increasing applications across surgical specialties. As described throughout this issue of *Clinics in Plastic Surgery,* ADMs are being used to correct a wide variety of aesthetic breast complications, including malposition, stretch deformity, coverage issues of wrinkling and rippling, and capsular contracture among others. In only a matter of time they will make their way into primary breast procedures, and they have already been implemented primarily for breast reductions/mastopexies as an internal sling or hammock. This section reviews early experience with the use of a periareolar piece alone to provide support and long-term maintenance of areolar diameter.

METHODS

For the use of donut-shaped grafts in periareolar mastopexy, cadaver laboratory studies were performed to determine the feasibility, best range of sizes, technical factors, and break strength. These studies were followed by a small clinical feasibility study with a 1 year maximum follow-up. A 3-cm inner circle diameter and 5.5-cm outer diameter of Strattice™ was inset as a "washer" after deepithelialization was performed. The outer diameter dermis was then sutured through the Strattice™/AlloDerm® at either 38 to 40 mm from the center of the nipple and then through the inner areolar dermis. Average nipple elevation was 2.5 cm, and four revision and four primary mastopexy breasts were performed.

In Vitro Studies

The authors first began in the cadaver laboratory testing various shapes, sizes, and materials. The inner diameter is deceptively large in position and the authors believed that a size of approximately 3 cm allowed for the material to be placed under the areola without extensive undermining. The outer diameter size range the authors judged to be ideal was closest to 5.5 cm (**Fig. 3**A). This diameter allows for lateral stability without the material buckling or folding back on itself, and extensive undermining is unnecessary (see **Fig. 3**B).

- The ADM was secured internally at the 3, 6, 9, and 12 o'clock positions with a 3-0 - poliglecaprone suture (Monocryl; Ethicon, Inc., Somerville, NJ, USA), at the periphery at the same points, and one additional suture between each quadrant.
- The ADM is then marked at 40 mm from the center or 1 cm outside the inner margin.
- The closure is then begun by grabbing the dermis of the outer diameter, placing a superficial skiving bite through the ADM at the 38 to 40 mm marked point, and then suturing the inner dermal areolar margin again at 3, 6, 9, 12 o'clock with a 3-0 Monocryl and at halfway points (see **Fig. 3**C).
- Next a 3-0 polyglycolide-poly-e-caprolactone copolymer suture (Monoderm Quill, Angiotech, Reading, PA, USA) is run, with the same sequence completing the closure. The quill is nice in that it can help create a slightly irregular border, mimicking more of an irregular areolar margin (see **Fig. 3**D).

The tension and bursting strength required in the laboratory, although not measured with any specific devices, is nearly impossible to break with excessive lateral pull after the closure is completed.

Satisfied with the basic technique refinements, the authors offered this repair to a small series of patients as an off-label application of the product. The company offered the product complimentary to the patient.

A series of eight patients elected this approach over the past year. The authors limited the inclusion to nipple repositioning less than 3 cm, which is their current criteria for offering this technique before transitioning to a circumvertical pattern. The average nipple elevation was 2.5 cm, and three patients had primary mastopexy and three were revision, with one in each group a bilateral mastopexy.

Early Clinical Results

Results have been good, with an average range of stretch from 0 to 8 mm postoperatively, with up to 1 year follow-up, 7-month average (**Table 1**). One patient had a suture track infection, necessitating

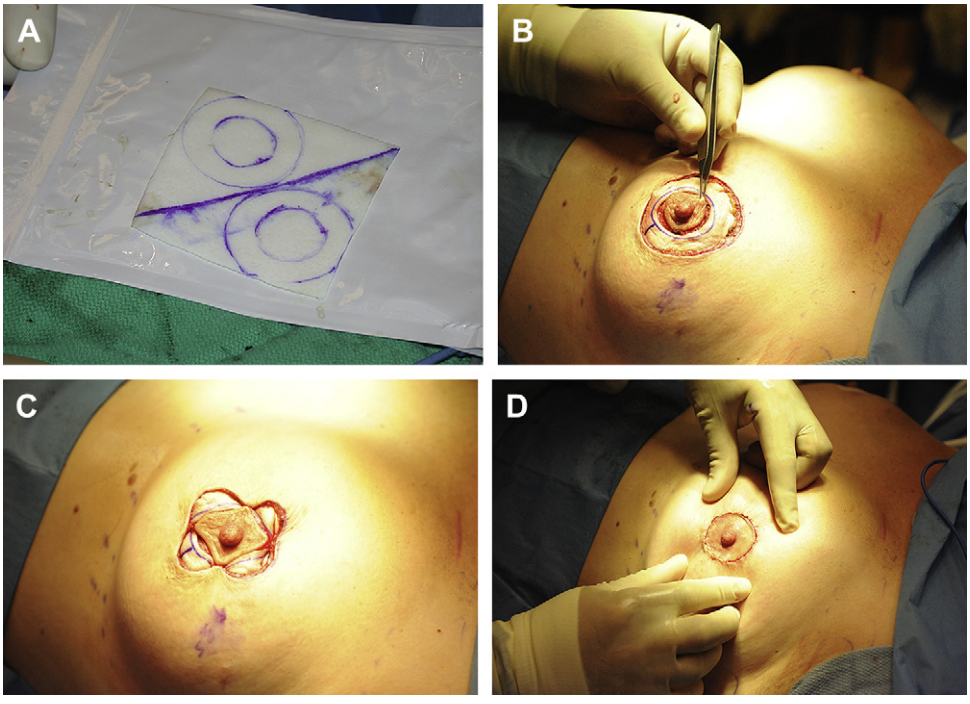

Fig. 3. (*A*) An 8 × 8 cm Strattice™ ADM graft marked for two donut pieces. (*B*) Placement of graft. (*C*) Closure at 3, 6, 9, and 12 o'clock positions before pursestring suture. (*D*) After closure with barbed suture.

removal of the nonintegrated ADM. This occurrence encouraged the authors to place a large Op-Site over the breast, leaving the nipple exposed to apply some external pressure and support the ADM through healing and minimizing activity with a sports bra for 4 weeks. Good ADM incorporation and no major infections, other exposures, extrusions, or significant hypertrophic scarring were seen with up to a 1-year follow-up.

The cadaver laboratory showed that the inner diameter required is somewhat smaller than anticipated, with the optimal range being approximately 3 cm and the outer diameter approximately 5.5 cm diameter. The goals are to provide enough of a base beneath the areolar margin but not devascularize the nipple, and to provide enough lateral support but not have the ADM fold back on itself. The restretch postoperatively was minimal in the first eight patients, with the average areolar diameter postoperatively being 44 mm (range, 38–48), with an average follow-up of 7 months, and restretch being 0 to 8 mm

Table 1
Areolar measurements with ADM donut/washer technique[a]

Breast # Period	Areolar Diameter Preoperatively	NAR set@ Surgery	NAR Postoperatively	Postoperative
1	58 mm × 56 mm	40 mm	43 mm	12 mo
2	65 mm × 60 mm	40 mm	44 mm	10 mo
3	62 mm × 60 mm	40 mm	48 mm	8 mo
4	68 mm × 60 mm	40 mm	42 mm	8 mo
5	48 mm × 55 mm	38 mm	38 mm	6 mo
6	48 mm × 50 mm	38 mm	46 mm	5 mo
7	75 mm × 70 mm	40 mm	44 mm	4 mo
8	56 mm × 60 mm	40 mm	42 mm	3 mo

Abbrevation: NAR, nipple areolar reconstruction.
[a] Primary author early series.

(**Fig. 4** for preoperative and postoperative patient views). An average of 15 minutes was added to the mean operating time.

Discussion of ADM in Mastopexy

Periareolar mastopexy as a stand-alone procedure continues to be one of the least popular mastopexy options among many plastic surgeons because of the limitations described with recurrent stretch, breast flattening, palpability, or suture track infection necessitating removal. Moreover, areolar diameter is not static but rather affected by factors such as temperature and stimulation. Fixation with a synthetic material interferes with this, so that instead of radial expansion and contraction, the nipple–areolar complex may seem to herniated ("Snoopy dog" deformity). A biologic material that becomes integrated may be more likely to perform as normal tissues while still preventing long-term expansion. Avoidance of a nondistensible purse-string suture will also prevent palpability, but use of resorbable materials leads to reexpansion to variable degrees.

ADMs are moving from purely reconstructive procedures into cosmetic applications in both revision and now occasionally primary aesthetic operations. Use of ADMs is quickly becoming standard for recurrent breast revision complications, such as malposition, stretch deformities, wrinkling, and rippling, and for reducing recurrent capsular contraction. They have also be used in augmentation mastopexy and reductions for patients who have sustained massive weight loss as internal hammocks and slings to support breast tissue and relieve the load and pressure on the lower breast. Whoever controls the lower pole of the breast maintaining the distance from nipple to inframammary fold controls the breast result over time.

Potential benefits of this periareolar ADM-assisted mastopexy include:

- Maintenance of the periareolar diameter after mastopexy
- Small amount of added projection to the subareolar region
- No additional vertical component or conversion to a circumvertical mastopexy
- No palpable periareolar suture with decrease in suture track infection.

Disadvantages of this technique include:

- Additional cost of the product
- Slight increase in surgical time
- Potential for extrusion or infection until revascularization.

Potential exists for using extra tissue obtained in processing of the ADM, which may decrease

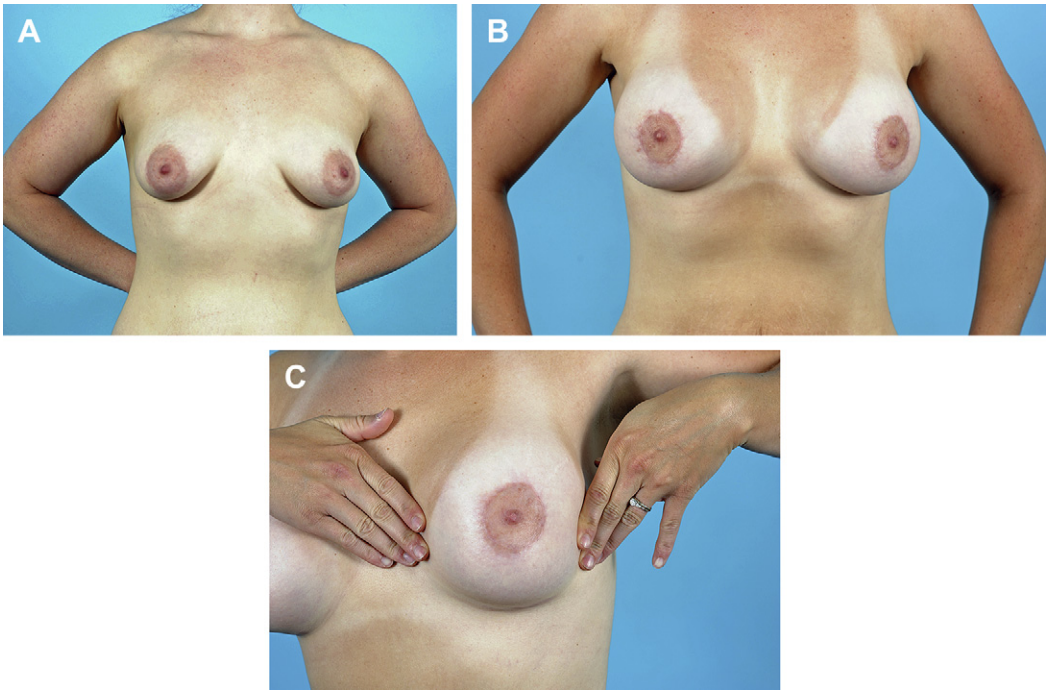

Fig. 4. (*A*) Preoperative view. (*B*) 1-Year postoperatively. (*C*) Close-up of postoperative view.

standard cost structure, and if extra tissue is available when using a larger piece for another part of the procedure and a patient requires a minimal mastopexy, this technique should be considered. In contrast to only revascularizing from one surface in most breast revisions and reconstructions, this technique has the advantage of revascularizing from both the superficial and deep surfaces so that delays or wound healing problems may be minimized.

The new reverse cutting needles are very sharp and do not dull during the repair. If increased stretch does occur over time, consideration for a longer lasting or permanent suture such as 3-0 or 4-0 Ethibond, at the 3, 6, 9, and 12 o'clock and intervening positions. Additional ADMs placed over a mastopexy buttress or pillar repair could also be considered.

CONCLUSIONS

With limited experience to date, the application of ADM materials in mastopexy is still emerging, but holds promise. For revision procedures, the rationale for its use is supported by considerable experience in related breast implant–based procedures, which may extrapolate to mastopexy without implants because the need for lower pole support is the same. Currently, indications for their use are not rigidly defined and require judgment, and further studies are needed. The donut graft for periareolar mastopexy seems to be a useful procedure for both primary and revision procedures based on preliminary data.

SUMMARY

Meshed ADM grafts seem useful in supporting mastopexies to minimize the chances of bottoming out and loss of upper pole projection. For periareolar mastopexy, the authors believe they have a good dimensional size for the "washer" piece of the ADM. The actual set diameter may be altered by the surgeon and at patient request, but it is typically set at 38 to 40 mm. This method adds potential projection to the areola; holds with acceptable range of restretch, certainly much better than conventional simple periareolar nonweave mastopexies; and adds minimal time to the procedure (an average of 15 minutes). Although very early in the healing process, it may provide another option in maintaining nipple–areolar diameter long-term. The authors had one patient with a suture track infection necessitating removal of the unincorporated material, and some adjustments in the intraoperative and postoperative course were subsequently made and continue to evolve.

REFERENCES

1. Spear SL, Low M, Ducic I. Revision augmentation mastopexy: indications, operations, and outcomes. Ann Plast Surg 2003;51(6):540–6.
2. Goulian D. Dermal mastopexy. Plast Reconstr Surg 1971;47(2):105–10.
3. Strombeck JO. Mammaplasty: report of a new technique based on the two pedicle principle. Br J Plast Surg 1960;13:79.
4. Rohrich RJ, Gosman AA, Brown SA, et al. Mastopexy preferences: a survey of board-certified plastic surgeons. Plast Reconstr Surg 2006;118(7):1631–8.
5. Hall-Findlay EJ. Pedicles in vertical breast reduction and mastopexy. Clin Plast Surg 2002;29(3):379–91.
6. Qiao Q, Sun J, Liu C, et al. Reduction mammaplasty and correction of ptosis: dermal bra technique. Plast Reconstr Surg 2003;111(3):1122–30.
7. Johnson GW. Central core reduction mammaplasties and Marlex suspension of breast tissue. Aesthetic Plast Surg 1981;5(1):77–84.
8. Góes JC. Periareolar mammaplasty: double skin technique with application of polyglactine 910 mesh. Rev Soc Bras Cir Plas 1992;7:1–3.
9. Góes JC. Periareolar mastopexy: double skin technique with mesh support. Aesthetic Surg J 2003; 23(2):129–35.
10. deBruijn HP, Johannes S. Mastopexy with 3D preshaped mesh for long-term results: development of the internal bra system. Aesthetic Plast Surg 2008; 32:757–65.
11. deBruijn HP, ten Thije RH, Johannes S. Mastopexy with mesh reinforcement: the mechanical characteristics of polyester mesh in the female breast. Plast Reconstr Surg 2009;124(2):364–71.
12. Dixon JM, Arnott I, Schaverian M. Chronic abscess formation following mesh mastopexy: case report. J Plast Reconstr Aesthet Surg 2010;63(7):1220–2.
13. Colwell AS, Breuing KH. Improving shape and symmetry in mastopexy with autologous or cadaveric dermal slings. Ann Plast Surg 2008; 61(2):138–42.
14. Góes JC, Bates D. Periareolar mastopexy with Forta-Perm. Aesthetic Plast Surg 2010;34(3):350–8.
15. Santucci RA, Barber TD. Resorbable extracellular matrix grafts in urologic reconstruction. Int Braz J Urol 2005;31(3):192–203.
16. Andrews JM, Aoki-Yshizuki MM, Martins DM, et al. An areolar approach to reduction mammaplasty. Br J Plast Surg 1975;28(3):166–70.
17. Bartels RJ, Strickland DM, Douglas WM. A new mastopexy operation for mild or moderate breast ptosis. Plast Reconstr Surg 1976;57(6):687–91.

18. Gruber RP, Jones HW Jr. The “donut” mastopexy: indications and complications. Plast Reconstr Surg 1980;65(1):34–8.
19. Spear SL, Kassan M, Little JW. Guidelines in concentric mastopexy. Plast Reconstr Surg 1990;85(6):961–6.
20. Spear SL, Giese SY, Ducic I. Concentric mastopexy revisited. Plast Reconstr Surg 2001;107(5):1294–9.
21. Hammond DC, Khuthaila DK, Kim J. The interlocking Gore-tex suture for control of areolar diameter and shape. Plast Reconstr Surg 2007;119(3):804–9.