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Breast

Early Experience with Mesh Suture for DIEP Flap Abdominal Site Closures

Paige N. Hackenberger, MD
Caitlin Stockslager, PA-C
Brianna Selimos, PA-C
Chad Teven, MD
Megan Fracol, MD
Michael Howard, MD

Background: The gold standard of microsurgical breast reconstruction is the deep inferior epigastric perforator (DIEP) free flap. As techniques have evolved, DIEP flaps have significantly reduced the morbidity previously caused by transverse rectus abdominis muscle (TRAM) and muscle-sparing TRAM flaps. However, abdominal wall complications continue to persist after DIEP flap surgery, with bulge rates reported as high as 33%.

Methods: The first 25 patients undergoing DIEP flap surgery with the use of Duramesh (MSI, Chicago, Ill.) by the senior author were identified. A retrospective chart review of patient and surgical details was performed. Charts were reviewed for outcomes, including surgical site infections, surgical site events, incisional hernia formation, and/or bulge. Standard descriptive summary statistics were used for patient characteristics, surgical details, and primary and secondary outcomes.

Results: Twenty-five patients were reviewed. Average follow-up duration was 216 ± 39 days. One patient (4%) developed a surgical site infection, and four patients (16%) developed a surgical site event. One patient developed a bulge, but no patients developed an incisional hernia.

Conclusions: Duramesh mesh suture provides a promising opportunity for DIEP surgeons to minimize both abdominal wall morbidity and mesh-related complications. Mesh suture can be used in a similar fashion as other sutures to perform primary closure of the anterior rectus sheath while also providing force-distribution benefits typically unique to planar mesh. This pilot study suggests that Duramesh is a safe, simple alternative to existing techniques in DIEP flap surgery and can be considered by microsurgeons to reduce fascial dehiscence, bulge, and/or hernia formation.
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INTRODUCTION

The gold standard of microsurgical breast reconstruction is the deep inferior epigastric perforator (DIEP) free flap.[1–3] It is well documented that methods that harvest the rectus abdominis muscle (ie, TRAM, VRAM, ORAM) can yield hernia formation rates from 3% to 24%.[4–9] As techniques have evolved, microsurgeons' ability to limit harvest to the suprafascial elements of this abdominally based autologous donor site has significantly reduced the morbidity previously caused by transverse rectus abdominis muscle (TRAM) and muscle-sparing TRAM flaps.[6–8,10] However, abdominal wall complications continue to persist after DIEP flap surgery, with reported rates of bulging from 2% to 33% and hernias up to 7%.[11,12]

DIEP surgeons may have varying levels of familiarity with incisional hernia (IH) prevention or treatment and may not have exposure to the rapidly changing hernia repair and abdominal wall landscape. This can lead to slow adoption of new methods when closing the anterior rectus sheath after DIEP flap harvests. Furthermore, using new techniques and/or materials can be daunting when there are limited data on safety and short-term outcomes to support a major change. Existing techniques for closure are varied and typically rely on primary repair with monofilament suture alone, or prophylactic application of a planar mesh. A large meta-analysis, specifically among DIEP donor sites, demonstrated that planar mesh significantly reduced IH formation; however, this is not without mesh-related risks.[11]

One explanation for the development of IH is due to "suture pull-through" or "cheese-wiring." This occurs when suture (such as monofilament, braided, and/

From the Division of Plastic and Reconstructive Surgery, Northwestern University Feinberg School of Medicine, Chicago, Ill.
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or barbed) is applied with too great of tension and slices through the same tissues it was meant to securely appose.[13] This mechanism is a result of focused pressure at the suture/tissue interface (STI) leading to either abrupt slicing of tissues or gradual local tissue ischemia and pressure necrosis that leads to failure over time. In DIEP surgery, this risk is mitigated by a limited fascial incision that only involves the anterior rectus sheath. Although short fascial incision techniques can further reduce donor-site complications, surgeon and patient factors may prevent widespread adoption of this technical difference.[14] Nevertheless, any derangement in the abdominal wall can lead to IH or bulge formation and warrants modification to limit this risk as much as possible.

Duramesh mesh suture (MSI, Chicago, Ill.) is a novel suture design created from braided and bonded fine polypropylene filaments, which form a hollow porous cylinder (Fig. 1) and seeks to solve the problem of suture pull-through. Duramesh was approved by the United States Food and Drug Administration in September 2022 as a polyfilament polypropylene suture that distributes forces at the STI by flattening like a ribbon to create a broad surface area and diffusing tension.[15] This, coupled with fibrovascular ingrowth among the multiple small filaments, has successfully decreased hernia formation seen in an in vivo porcine laparotomy model.[16,17] Duramesh has been used in a variety of clinical settings since its approval for human use within the European Union and United Kingdom in 2021. These include indications such as elective hernia repair, laparotomy closures, hiatal hernia repairs, rectus diastasis plication, and orthopedic tendon repairs.[18,19] Early data from our institution demonstrate the wide applicability by surgeon discipline and indication, with a clear focus on utilization for abdominal wall repair.[18] We report the microsurgeon's perspective with clinical use of Duramesh for closure of the abdominal fascia following DIEP flap donor-site surgery.

Takeaways

Question: How might the use of a novel mesh suture device improve abdominal donor-site outcomes in the deep inferior epigastric perforator (DIEP) free flap breast reconstruction population?

Findings: We report one abdominal bulge, but no incisional hernia formations after a retrospective review of the first 25 breast reconstruction patients to have mesh suture closure of the anterior rectus sheath after DIEP flap harvest.

Meaning: Limiting abdominal wall morbidity after DIEP flap breast reconstruction through the use of a novel mesh suture device can be performed quickly, safely, and with promising outcomes.

METHODS

Creation of a mesh suture patient registry using retrospective data collection techniques was approved by the Northwestern University institutional review board. The first 25 patients undergoing DIEP flap surgery with the use of Duramesh by the senior author were identified through institutional implant logs. Each implant log was further reviewed by the study team, including evaluation of corresponding operative reports, to verify use of Duramesh for closure of the abdominal fascia after DIEP flap harvest.

Duramesh was implanted following guidelines within the instructions for use, included in the packaging of each device.[20] In DIEP patients within this cohort, mesh suture was used in a running fashion, spaced 7–10 mm, and tied with four alternating throws (Fig. 2).

After the cohort was defined, we performed a retrospective chart review of the electronic medical record to evaluate patient characteristics, surgical details, and short-term outcomes of interest. Patient characteristics included demographics, cancer history, and surgical history. Surgical details included DIEP flap dissection, device suture size and needle type, and number of mesh suture implants used. Patient charts were reviewed for documented follow-ups and outcomes of interest, defined as surgical site infections (SSI), surgical site events (SSE), IH formation, and/or bulge. No new data entries for follow-up were added after November 19, 2023.

The primary outcomes were incidence of SSI and/or SSE as defined by Majumder et al.[21] SSI include superficial, deep, and/or organ/space infections. SSE include seroma, hematoma, soft tissue breakdown, fascial dehiscence, cellulitis, suture granuloma, chronic draining sinus, and/or enterocutaneous fistula formation. The secondary

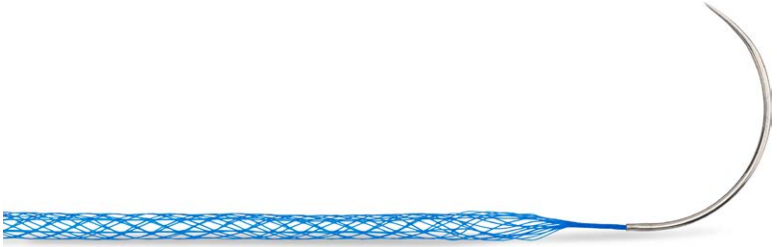

Fig. 1. Duramesh mesh suture device (item MSI-301 pictured). Image courtesy of Mesh Suture Inc. Used with permission.

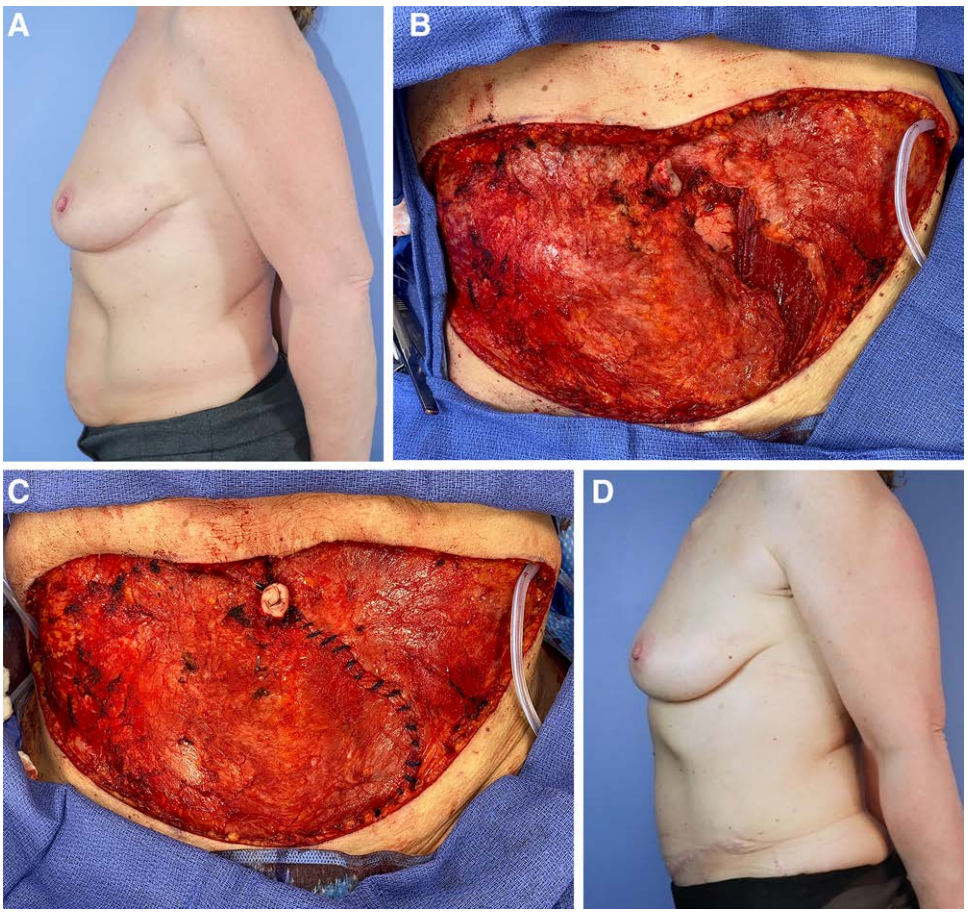

Fig. 2. Use of Duramesh mesh suture to close anterior rectus sheath after unilateral left-sided DIEP flap harvest. A, Left lateral view of patient's preoperative abdominal contour. B, Defect in anterior rectus sheath after DIEP flap harvest. C, Completed Duramesh mesh sutured closure of anterior rectus sheath defect. D, Left lateral view of patient's postoperative abdominal contour.

outcomes were incidence of IH or bulge after abdominal fascia closure with Duramesh. IH and bulge were identified through physical examination during routine follow-up visits with the primary surgeon. An IH was defined as a palpable fascial defect on physical examination, whereas a bulge was defined as visible and palpable laxity in the abdominal wall without a palpable fascial defect.

Standard descriptive summary statistics were used for patient characteristics, surgical details, and primary and secondary outcomes. Continuous variables were reported as means with SDs and categorical variables were reported as proportions. Data were managed and analyzed using Microsoft Excel (Redmond, Wash.).

RESULTS

The first 25 patients who underwent mesh sutured closure of DIEP flap abdominal donor-site fascia by the senior author were identified. Patients were on average 51.0 ± 10.7 years of age and 92% identified as White. Average body mass index was 28.3 ± 3.8 kg/m^2. Eighty-four percent (N = 21) had a breast cancer history, whereas 16% (N = 4) underwent prophylactic mastectomies due to genetic predisposition. Of the 21 patients with breast cancer, 57% (N = 12) had undergone chemotherapy and 38% (N = 8) had a history of breast radiation treatment. 72% (N = 18) of patients had a history of abdominal and/or abdominal wall surgery. Fourteen of the 18 patients (77%) who had a history of abdominal surgery had at least one genitourinary surgery (ie, cesarean section, hysterectomy, salpingectomy and/or oophorectomy, etc.). Only one patient had undergone a previous hernia repair. No patients had a documented hernia at the time of their DIEP surgery.

The most common Duramesh item type used was MSI-301, which corresponds to a #1 suture size and HR48 needle size. The average number of mesh sutures used for each case was 1.4 ± 0.5 (range 1–2). Typically for a bilateral DIEP, one Duramesh suture is used per hemiabdomen, for a total of two sutures. All cases were performed in class I ("clean") Centers for Disease Control wounds. Patient demographics and surgical characteristics are further summarized in Table 1.

Average follow-up duration was 216 ± 39 days (range 121–289 days). In total, 80% (N = 20) had no complications. The overall SSI rate was 4% (N = 1) and overall SSE rate was 16% (N = 4). Among SSI, 4% (N = 1) developed a

Table 1. Patient and Surgical Details

Patient Demographics (N = 25)	
Age (y)	51.0 ± 10.7
White	92% (23)
Body mass index (kg/m²)	28.3 ± 3.8
History of breast cancer	84% (21)
Chemotherapy	12
Radiation	8
Prior abdominal wall surgery	72% (18)
Surgical Details	
Device used*: suture size, needle size	
MSI-100: 2-0, small (DR20)	—
MSI-200: 0, small (HR22)	2
MSI-201: 0, large (HR48)	—
MSI-300: 1, small (HR26)	3
MSI-301: 1, large (HR48)	31
MSI-500: 2, small (HR26)	—
MSI-501: 2, large (HR50)	—
Average devices used per surgery	1.4 ± 0.5

*Device numbers taken from Duramesh product catalog. More than one device may be used per surgery; thus, numbers do not sum to total number of patients.

Table 2. Abdominal Wall Outcomes (N = 25)

Follow-up Duration (d)	**216 ± 39**
Bulge formation	4% (1)
Hernia development	0% (0)
SSI	4% (1)
Superficial	4% (1)
SSE	16% (4)
Seroma	4% (1)
Soft tissue breakdown	12% (3)

SSE, surgical site event; SSI, surgical site infection.

superficial infection. There were no deep or organ/space infections. Among SSE, 4% (N = 1) developed seroma and 12% (N = 3) developed soft tissue breakdowns. There were no hematoma, fascial dehiscence, cellulitis, suture granuloma, chronic draining sinus, or enterocutaneous fistula events. There was one (4%) incidence of bulge development first noticed on clinical examination two months postoperatively in a patient with a history of two abdominal procedures. Despite no palpable hernia on clinical examination, computed tomography imaging was obtained and confirmed no fascial defects. There were no IH formations. These outcomes are presented in Table 2.

DISCUSSION

DIEP flaps are an increasingly common breast reconstruction technique due to growing rates of mastectomies and patient preference for autologous options.[3,22] As reconstructive surgeons, our goal is to provide optimal reconstruction while minimizing the functional and cosmetic impact on the donor site. DIEP flaps have been shown to halve the risk of IH and/or bulge development at the abdominal wall compared with TRAM flaps.[6] Among many other studies, the American Society of Plastic Surgeons autologous breast reconstruction work group also acknowledges these differences by agreeing that DIEP and TRAM procedures only have comparable abdominal donor-site morbidity when mesh is used in donor-site closures for TRAM flap harvests.[2] For patients who develop IH, there is significant healthcare expenditure and resulting strain on the patient, which may reduce postoperative satisfaction.[23]

Although DIEP flap dissection limits abdominal wall morbidity, patients still develop complications related to the abdominal donor site. Development of IHs or bulges can cause bowel dysfunction, pain/discomfort, and poor cosmesis. Minimizing this risk in DIEP flap surgery is therefore paramount to patient safety and satisfaction. Prior studies have identified patient (increased age, obesity) and operative (use of ≥2 perforators, use of lateral row perforator, use of perforators from both the medial and lateral rows, prolonged surgical time) risk factors for development of IH or bulges.[24–28] Previous studies suggest that use of prophylactic mesh provides a mechanical advantage in some DIEP patients to prevent IH formation.[11,29,30] DIEP surgeons must carefully consider a multitude of patient and surgical characteristics, such as these factors, to assess risk for abdominal wall hernia or bulge in each patient. These factors may influence which fascial closure technique is selected to best mitigate perceived risk of future morbidity. However, there is not a particular patient subgroup or risk stratification system to specify for whom planar mesh is likely to be most favorable in the DIEP-based breast reconstruction population.

Given this uncertainty, microsurgeons must strike a balance to appropriately protect against future IH formation while also limiting the risks that accompany techniques such as prophylactic planar mesh application. Downsides of planar mesh include increased operative time, increased tissue dissection, and introduction of large amounts of foreign material; these put patients at risk for wound healing complications, seroma/hematoma, and/or infection.[31–34] These risks are significant enough in the hernia repair population that the Ventral Hernia Working Group provides a classification system to help stratify risk of surgical site occurrences and influence mesh decision making to limit all complications.[35] Furthermore, Fischer et al have described the development of a surgical risk stratification tool that identifies patients at greatest risk for IH development.[36] Through similar modeling and careful selection of high-risk patients, prophylactic mesh may be further targeted for use in DIEP patients with high predicted risk.

Successful surgical closures in areas of high-tension, such as the abdominal wall, require that the ultimate tensile strength of the repair remains greater than the forces applied.[37] To prevent acute or chronic suture pull-through in the abdominal wall, this has traditionally been accomplished through minimizing tension and/or using planar meshes that work to distribute forces over a large surface area.[38,39] The hernia literature suggests that sheets of mesh that are cut into 2-cm-wide strips and are used as suture ("mesh strips") can maintain force distribution at the STI while simultaneously avoiding these common risks.[37,40,41] However, performing this

off-label technique is not standardized and can be too labor intensive for some surgeons and, thus, limits its generalizability.

Duramesh mesh suture has standardized the mesh strip proof-of-concept and increased the accessibility of this technique across various disciplines.[18] It provides a promising opportunity to balance the simplicity of running suture closure of the anterior rectus sheath with the force-distribution principles used by sheets of mesh, all while limiting tissue plane dissection and foreign material implantation.

Anecdotally, the operative time needed to repair the fascia with Duramesh in the senior author's practice is approximately 5 minutes. This is compared with 10–15 minutes required for the previous interrupted repair technique, and 20 minutes or greater for placement and fixation of planar mesh. With one minute of operating room time estimated to cost between $36 and $62, a technique that reduces operative time by 10–20 minutes can contribute in real time toward intraoperative cost savings.[42–44] This time saver is augmented when performing bilateral reconstructions, and must be compared with any materials cost differences related to use of Duramesh in place of other products.

In addition, these early data suggest that mesh suture is associated with safe use in this population, as demonstrated by our report outlining a minor complication profile. We report no fascial dehiscence, no hernia formation, and only one (4%) bulge development in this cohort. This is at least equivalent to, if not lower than, the literature reported rates for both hernia (0.7%–7.1%) and bulge formation (2.3%–33%).[11,12,24] With only one seroma at the donor site (4%), this outcome is much less than the 13% rate associated with abdominal donor sites closed in a variety of techniques.[24] Lastly, our reported rate of delayed wound healing (16%) is equivocal to those in the literature.[24] The lack of other serious outcomes such as deep and/or organ space infections, fascial dehiscence, and chronic draining sinus further support the safety profile in DIEP patients. These outcomes suggest that Duramesh can be readily and simply used in DIEP flap abdominal fascia closures without increasing risks and with potential to reduce hernia or bulge formation.

LIMITATIONS

This study has several limitations, including retrospective chart review, length of follow-up duration, and small sample size. As such, rare complications or late-occurring complications may not be captured by these reported outcomes; these may include incomplete capture of IH/bulge development given average follow-up of less than 1 year. Furthermore, this study does not compare directly to suture-only or planar mesh for DIEP donor-site repairs. A larger, matched-control study is underway with the hopes to better answer for whom mesh suture may be best indicated in the DIEP patient population. No cost data were collected as part of this study; however, costs of the device are typically country-, institution-, and/or insurance provider–specific and can vary widely. Lastly, the study team recognizes the potential conflicts of interest with Duramesh and MSI, including the suture's development by a member of the Northwestern Feinberg School of Medicine Department of Surgery, one author's (MAH) investment, and the partial support of Dr. Hackenberger's salary by an unrestricted grant of $15,000.

CONCLUSIONS

Duramesh mesh suture provides a promising opportunity for surgeons to minimize abdominal wall morbidity and avoid mesh-related complications following DIEP flap surgery. Mesh suture can be used to perform primary sutured closure of the anterior rectus sheath while also providing many force-distribution benefits derived from planar mesh. This pilot study suggests that Duramesh is a safe, simple alternative to existing fascia closure techniques in DIEP flap surgery with equivalent, if not reduced complication rate and reduced operative times. It may be considered by microsurgeons as a technique to reduce fascial dehiscence, bulge, and/or hernia formation in their postoperative patients.

Michael Howard, MD
1000 N Westmoreland Rd
Pavilion B, Level 2
Lake Forest, IL 60045
E-mail: michael.howard@nm.org

DISCLOSURES

The Northwestern Department of Surgery received an unrestricted educational grant of $15,000 from MSI, which has partially supported Dr. Hackenberger's salary. Dr. Howard is an investor in MSI and owns four shares of stock in the company. All the other authors have no financial interest to declare in relation to the content of this article.

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