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Reconstructive

# Mesh Strip Repair for Midline Ventral Hernias: A Case Series

Benjamin A. Sarac, MD*
Paige Hackenberger, MD†
Jeffrey E. Janis, MD, FACS*

**Background:** Polypropylene mesh strip repair is a novel method of hernia closure. Currently, there is limited representation in the literature regarding both the reproducibility of this method and its outcomes. The present study sought to analyze a second institution's experience with fascial closure using the mesh strip technique with long-term follow-up.

**Methods:** A retrospective review of all patients undergoing abdominal wall reconstruction by the senior author was performed. Patients undergoing midline ventral hernia repair with mesh strip only fascial closure and greater than 1 year follow-up were including for analysis. Demographic data; operative details; and outcomes, specifically presence and timing of hernia recurrence, were recorded.

**Results:** Eighteen patients met inclusion criteria. Average follow-up was 860 ± 307 days. Nine patients (50%) had recurrence of their hernia after repair. Average time to recurrence was 602 ± 406 days, with the earliest recurrence occurring at 126 days postoperatively. Seven patients (39%) underwent concurrent anterior component separation (four unilateral, three bilateral), of which there were three recurrences, all occurring in patients with bilateral anterior component separation.

**Conclusions:** The mesh strip repair is a novel technique that shows uncertain reproducibility of outcomes, specifically with concurrent component separation techniques. With the recent Food and Drug Administration approval of a mesh suture, further multi-institutional analysis will allow for better characterization of the outcomes and indications for this technique. *(Plast Reconstr Surg Glob Open 2024; 12:e5643; doi: 10.1097/GOX.0000000000005643; Published online 20 March 2024.)*

## INTRODUCTION

Ventral hernias occur in 10%–30% of patients after exploratory laparotomy. One of the primary goals of subsequent abdominal wall reconstruction is minimization of recurrence. The role of mesh reinforcement in reducing hernia recurrence has been well-described as superior to suture-only repair.[1–3] Because the abdominal wall functions as a pressurized cylinder, there is amplified tension at the suture–tissue interface after reconstruction, which is prone to suture pull-through and subsequent repair failure.[4,5]

To combine the benefits of suture with the reinforcement of mesh, Dumanian et al reported an innovative technique of mesh strip hernia repair, showing increased strength of early wound healing in an experimental rat model.[4] The key to this technique is the increase in surface area of mesh used as a suture compared with monofilament suture, an advantage that serves to reduce the failure rate of traditional suture repairs. Given previous studies showing increased tensile strength of this approach, this innovation is postulated to be advantageous to any hernia surgeon's toolbox.[5–7]

Regardless of promising study results, recurrence rate is one of the critical measures of value in hernia surgery. Traditional techniques involving monofilament suture or planar mesh yield 10-year hernia recurrence rates of 37%, 64%, and 73% after primary, incisional, and multiincisional hernias.[8] Although the original papers describing mesh strip repairs reported a recurrence rate of only 3.7% with an average follow-up of 234 days, the literature

*From *The Ohio State University Department of Plastic and Reconstructive Surgery, Columbus, Ohio; and †Northwestern University Division of Plastic and Reconstructive Surgery, Chicago, Ill.*

*Received for publication October 1, 2023; accepted January 16, 2024.*



DOI: 10.1097/GOX.0000000000005643

Disclosure statements are at the end of this article, following the correspondence information.

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currently lacks evidence to support long-term recurrence reduction beyond this time frame.[6] Further elucidating the long-term value of mesh strips is important, as hernia recurrences frequently occur well beyond the first year after repair.[9]

While a proprietary mesh suture[10] has recently garnered Food and Drug Administration (FDA) clearance, the originally described technique involves use of two centimeter wide strips of macroporous polypropylene mesh to accomplish the same principle of widely distributed closure forces. The present study sought to analyze our experience employing the mesh strip technique with a long-term (greater than one year) follow-up.



## METHODS

A retrospective review of a prospectively collected abdominal wall reconstruction database of patients operated on by a single surgeon (J.E.J.) was reviewed for records from September 2013 through December 2022. Inclusion criteria consisted of patients undergoing abdominal wall reconstruction for midline ventral hernia repairs using the mesh strip technique. Patients were excluded if they did not have more than 1 year of follow-up or had a planar mesh placed in addition to the mesh strips.

Variables collected included demographic information; medical comorbidities; Kanters grade[11]; operative details; recurrence at various time points; and surgical site occurrence (SSO), defined as any surgical site infection (SSI), seroma, wound dehiscence, enterocutaneous fistula, wound cellulitis, nonhealing incisional wound, fascial disruption, skin or soft tissue ischemia, skin or soft tissue necrosis, wound serous or purulent drainage, stitch abscess, hematoma, infected or exposed mesh, and need for mesh or mesh strip removal.[12] When hernia recurrence was suspected on physical examination, it was verified by computed tomographic imaging. Data on hospital length of stay and daily oral morphine equivalents administered were also collected.

This study received institutional review board approval from the Ohio State University Office of Responsible Research Practices (IRB #2015H0105).

### Operative Technique and Materials

The mesh strip hernia repair technique used was modeled off the original description by Dumanian et al.[4] Complete details of this technique can be found in the Society of Gastrointestinal and Endoscopic Surgeons (SAGES) *Manual of Hernia Surgery* (2nd Edition).[13] The original description included use of Prolene Soft Mesh (Ethicon, Somerville, N.J.) cut into 2-cm wide strips and subsequently pulled through the rectus complex using a number one polypropylene "guiding suture." Our study used a different midweight, macroporous polypropylene mesh (Parietene; Covidien, Dublin, Ireland) threaded through the rectus complex with the distal tip of a Pulvertaft tendon weaver instead of a number one polypropylene suture tied to the end of each mesh strip.[14] (**See Video 1 [online]**, which displays the full operative technique.) Mesh difference was related to hospital formulary differences rather than intentional exploration between different mesh brands. Table 1, adapted from Wang See et al, illustrates the similarities between these products, both classified as midweight, macroporous uncoated polypropylene (PP) meshes.[15]

### Takeaways

**Question:** What is the recurrence rate for midline ventral hernia repair with the mesh strip fascial closure technique?

**Findings:** This was a case series, which reviewed patients who had midline ventral hernia repair with the mesh strip fascial closure and follow-up of more than 1 year. Eighteen patients were identified, of which nine (50%) had recurrence of hernia.

**Meaning:** The high rate of hernia recurrence was not in accordance with previous studies on the technique, and a standardization of technique and materials may help elucidate the indications and advantages of this repair for any hernia surgeon's toolbox.

## RESULTS

A total of 388 total patients were reviewed, and of these 43 (11%) underwent mesh strip repair. Eighteen patients met inclusion criteria of having mesh strip only repair for midline hernia with follow-up greater than one year. Demographic and baseline characteristics are shown in Table 2.

Table 3 details limited operative details and outcomes. Seven patients (39%) underwent a concomitant anterior component separation—four unilateral, three bilateral. The average time of the most recent follow-up was 860 days postoperatively, with a maximum of 1151 days.

The primary outcome was any hernia recurrence. Nine of eighteen patients (50%) had computed tomographic scan-documented hernia recurrence at an average of 602 days postoperatively. The earliest recurrence occurred on postoperative day 126. Four of the nine recurrences occurred within 1 year, while the remaining five occurred after 1 year. There were a total of nine SSOs (50%). See Table 4 for details regarding each SSO. In total, six of the SSOs were related to wound complications (either superficial skin necrosis or small areas of dehiscence). The remaining three SSOs were infectious in etiology, with one superficial abscess that spontaneously drained, and two seromas with associated cellulitis. Only one of the SSOs required operative intervention as a result of the operation (patient 6, who had excision of an area of fat necrosis at 6 months), though there was one additional return to the operating room (patient 2) for removal of infected previously incorporated mesh that was not removed at the time of the mesh strip operation, as it was well incorporated into the native tissue.

Lastly, patients were analyzed among those who received any component separation (unilateral or bilateral, anterior and/or posterior), as shown in Table 5. Of the seven patients who underwent any unilateral or

**Table 1. Definitions of SSI and Surgical Site Events (SSE)**

| | Definition |
|---|---|
| **SSI** | Events occurring within 90 days of hernia repair or up to 1 year for deep and organ/space SSIs with presence of implant |
| Superficial | Infection involving skin or subcutaneous tissue along with 1+ of the following: purulent drainage, organisms isolated from fluid/tissue, 1 sign of inflammation (pain/tenderness, induration, erythema, local warmth), deliberate wound opening by surgeon, or surgeon declaration |
| Deep | Infection involves deep soft tissues (fascia and/or muscle) with 1+ of the following: purulent drainage, fascial dehiscence with signs of inflammation, deliberate fascial separation by surgeon, deep abscess identified by direct examination, reoperation or radiologic verification, or surgeon declaration |
| Organ/space | Infection involves anatomic structures not opened or manipulated by operation or peritoneal cavity with 1+ of the following: purulent drainage from drain or incision into organ/space, organisms isolated by aseptic culture, identification of abscess by direct identification, reoperation, or radiologic verification, or diagnosis by surgeon declaration |
| **SSE** | Events occurring within 90 days of hernia repair |
| Seroma | Collection of serous fluid in abdominal wall that is either symptomatic (causes pain/discomfort) or requires intervention |
| Hematoma | Collection of blood in the abdominal wall that is either symptomatic (causes pain/discomfort) or requires intervention |
| Soft tissue breakdown | Skin and/or adipose tissue breakdown requiring debridement or packing. Does not include fascial dehiscence |
| Fascial dehiscence | Fascial separation without evidence of infection or inflammation requiring clinical intervention |
| Cellulitis | Erythema of skin or subcutaneous connective tissue that does not involve the surgical site but requires treatment with antibiotics |
| Suture granuloma | Localized inflammatory reaction in response to retained suture material without evidence of infection requiring intervention |
| Chronic draining sinus | Sinus tract in abdominal wall draining serous or fibrinous fluid without evidence of gross purulence |
| Enterocutaneous fistula | Connection from the gastrointestinal tract to the skin with spillage of enteric contents |

Table adapted from Majumder et al.[12]

**Table 2. Demographics and Preoperative Characteristics (N = 18)**

| | |
|---|---|
| Age | 56 ± 15 |
| Female gender | 13 (72%) |
| Body mass index | 34 ± 14 |
| Hypertension | 8 (44%) |
| Chronic obstructive pulmonary disease | 2 (11%) |
| Diabetes | 5 (28%) |
| Immunosuppression | 4 (22%) |
| Any smoking history | 6 (33%) |
| Hernia width (cm) | 9.0 ± 3.0 |
| No. reported prior hernia repairs | 2.0 ± 1.8 |
| Kanters score[11] | |
| 1 | 1 (6%) |
| 2 | 15 (83%) |
| 3 | 2 (11%) |

Data are presented as n (% of column) or mean ± SD unless otherwise noted.

**Table 3. Operative Details and Postoperative Outcomes (N = 18)**

| | |
|---|---|
| Anterior component separation | 7 (39%) |
| Length of postoperative admission (d) | 3.4 ± 1.5 |
| Documented follow-up duration (y) | 2.4 ± 0.8 |
| Surgical site occurrence | 9 (50%) |
| Hernia recurrence | 9 (50%) |
| Recurrence <1 year postoperatively | 4 |
| Recurrence >1 year postoperatively | 5 |
| Time to recurrence (y) | 1.7 ± 1.1 |

Data are presented as N (% of column) or mean ± SD unless otherwise noted.

bilateral component separation, there were three recurrences (43%), compared with six recurrences (55%) in those who did not have a component separation. However, of those in the component separation who did have a recurrence of hernia, all three had bilateral anterior component separations, compared with none among those with unilateral anterior component separation.

## DISCUSSION

The mesh strip technique is an innovative approach to hernia repair. By providing eight times the surface area compared with monofilament sutures, "cheese-wiring" caused by suture pull-through can be mitigated.[4–7] Mesh strip repairs have limited representation in surgical literature, which may be partly attributed to the off-label use of cut planar mesh. However, with the new FDA clearance, the patented mesh suture combined device that includes a swaged-on tapered needle may increase visibility and practicality of this method for some surgeons.[10,17] Despite a paucity of literature, the mechanical properties have been tested in laboratory studies and case reports and have shown favorable outcomes in several populations.[16,18–22]

Limited long-term follow-up studies, however, prevent full characterization of the optimal indications, contraindications, and benefits of the mesh strip technique. The current study sought to aid the literature by providing long-term follow-up (minimum 1 year) of patients who underwent the mesh strip fascial closure technique. Among the 18 patients who underwent mesh strip repair

**Table 4. Description of SSI and SSE Outcomes**

| Age, Gender | SSI and/or SSE | Time of Development | Treatment |
|---|---|---|---|
| 62, F | Superficial infection | 6 weeks | Treated at outside facility with complete resolution |
| 51, F | Superficial infection<br>Soft tissue breakdown | 6 weeks | Infection resolved with oral antibiotics. Soft tissue breakdown and associated fat necrosis surgically excised |
| 57, F | Superficial infection<br>Seroma | 4 weeks | Resolved with seroma aspiration and oral antibiotics |
| 58, F | Soft tissue breakdown | 6 weeks | Resolved with local wound care |
| 39, F | Soft tissue breakdown | 6 weeks | Resolved with local wound care |
| 40, F | Soft tissue breakdown | 6 weeks | Resolved with local wound care |
| 72, M | Soft tissue breakdown | 6 weeks | Resolved with local wound care |
| 34, F | Soft tissue breakdown | 6 weeks | Resolved with local wound care |
| 77, F | Soft tissue breakdown | 12 weeks | Resolved with local wound care. Underwent abdominal reoperation unrelated to mesh strips |

**Table 5. Mesh Materials Comparison**

| Product (Manufacturer) | Composition | Pore Size (mm) | Absorbable? | Weight ($g/m^2$) | Filament | Mechanical Properties | Advantages |
|---|---|---|---|---|---|---|---|
| Parietene (Covidien) | Polypropylene | 0.8 | No | 80–100 | Multifilament | Tensile strength of 38.9 ± 5.2 N/cm in longitudinal direction and 26.6 ± 4.2 N/cm in transverse | Low infection rate |
| PROLENE (Ethicon) | Polypropylene | 0.8 | No | 80–100 | Monofilament | Tensile strength of 156.5 N/cm | Facilitates fibrovascular ingrowth, infection resistant. Mesh compliance is improved |

Table adapted from Wang See et al.[15]

of midline ventral hernias and met the minimum follow-up period, there was a 50% recurrence rate.

We report a higher recurrence rate than previous mesh strip studies. Comparatively, Lanier et al, who first described the technique, published a 4% recurrence rate, in a population with fewer current/recent smokers (10.3% versus 33%) and fewer patients qualifying as immunosuppressed (18.7% versus 22%).[6] It should be noted, however, that "smokers" in our cohort were those who had any smoking history (no active smokers were offered reconstruction), and immunosuppression included any form of immunosuppression, whereas the aforementioned article does not specify, which may lead to a discrepancy when comparing groups. Four of our reported recurrences were documented within one year of repair. However, while the recurrence rate diverges, so does the average follow-up duration. Our study reports an average documented follow-up of 860 days, compared with 234 days in the study by Lanier et al. This discrepancy is important to note, as up to 80% of hernia recurrences can occur in the first two years postoperatively.[23] While risk for hernia recurrence is undoubtedly multifactorial, the limited length of follow-up in prior studies may have failed to capture the primary outcome. In our mesh strip cohort, we report an average time to hernia recurrence of 602 days. As such, it is likely that previous studies were subject to length-time bias, thus incompletely capturing this outcome.

Importantly, differences in technical details may confound the results compared with those of the initial studies. Although the core elements of our approach are consistent with those described by Lanier et al, variation in mesh manufacturer and method of mesh strip deployment may contribute to outcome differences not captured in this study.[6] As outlined in Table 1, both Prolene and Parietene are macroporous polypropylene meshes with tantamount qualities. These meshes diverge with respect to tensile strength, which could predispose patients to hernia recurrence. However, data on different types of mesh material (ie, absorbable synthetic, biologic, etc.) to create the mesh strip does not exist and is a topic for additional research and consideration as this technique continues to gain traction. Additionally, the technique of the senior author uses a Pulvertaft tendon weaver for mesh strip passing, which may have increased the size of holes in the rectus complex compared with those created when using a #1 polypropylene guide suture, described by Dumanian.[13] However, the technique mentioned in the 2016 article by Lanier et al[6] differs from the published SAGES technique. The 2016 description by Lanier et al describes the use of a small hemostat to pierce the abdominal wall and thread the mesh strip; this highlights the multiple techniques used in the evolution of the mesh strip technique and the variability with which it is performed across time, institutions, and individual surgeons. This increased size over the length of an average laparotomy incision of 27 cm, as described by Israelsson and Jonsson,[24] could contribute to a greater defect area in the abdominal wall, potentially predisposing the patient to recurrence. However,

given that the tendon weaver tip size is less than 1 cm in diameter, it is unknown if this technical difference would explain the difference in rates of hernia recurrence, as the literature shows that port sites under one centimeter do not require fascial closure.[25] The newly available mesh suture product (with its swaged-on taper needle), however, may provide consistency in variables of technique which will facilitate more reproducible outcome studies in the future. Notably, mesh strips and the new mesh suture device have differences. While mesh suture has a cylindrical shape, which flattens upon deployment under tension, new mesh strips are two-dimensional. These differences in design may have unknown impacts on tensile forces and interaction with the native tissue.

Although the reported hernia recurrence rate is greater than in the comparative cohorts, when stratified by use of component separation, recurrence rates were similar between groups in our cohort. It is important to note, however, that all three patients who had a bilateral anterior component separation during their repair had documented hernia recurrence. Although this is a small, underpowered number of patients, there is a level of caution for use of this technique in closures requiring component separation techniques. Patients with poor abdominal wall compliance, large hernia defects, elevated intraabdominal pressures, or significant loss of domain may require component separation at time of incisional hernia repair to allow for primary fascial closure. Component separation, therefore, is likely a proxy by which other variables contributing to high risk for hernia recurrence are synthesized at the time of operative repair. As such, component separation rates may be confounded by underlying physiologic attributes which predispose to poor outcomes which may not be completely captured in our data collection.

## LIMITATIONS

This study is limited by sample size, which reduced the ability to draw firm conclusions based on rates of hernia recurrence. Further, the retrospective, single-surgeon experience does not allow for external validity of the results. As mentioned previously, the effects of differences in specific brand of mesh used and method of mesh strip passing are unknown and may represent an inability to properly compare results of this study to prior studies describing this technique.

## CONCLUSIONS

This study represents the first to analyze the mesh strip fascial closure technique with a minimum of 1 year follow-up. The current technique did not prove to obtain the same low hernia recurrence rate as the original description by Lanier et al.[6] However, it should be noted that patients undergoing concomitant component separation at the time of mesh strip repair, specifically bilateral anterior component separation, had high rates of hernia recurrence and there should be caution when performing this technique in combination with mesh strip repair. Larger, multi-institutional analyses will allow for better characterization of the proper utilization of the mesh strip technique, and FDA approval of the patented mesh suture combined device will help facilitate this process for standardization of technique.

***Jeffrey E. Janis, MD, FACS***
915 Olentangy River Road, Suite 2100
Columbus, OH 43212
E-mail: jeffrey.janis@osumc.edu
Twitter: @jjanismd
Instagram: @JeffreyJanisMD

## DISCLOSURES

*Dr. Janis receives royalties from Thieme and Spring Publishing. The remaining authors have nothing to disclose. No funding was received for this article.*

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