Hernia (2024) 28:2207–2216
https://doi.org/10.1007/s10029-024-03133-6

ORIGINAL ARTICLE

Long-term outcomes of open midline ventral hernia repair using a narrow well-fixed retrorectus polypropylene mesh

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Received: 28 May 2024 / Accepted: 5 August 2024 / Published online: 30 August 2024

Abstract

Introduction The ultimate measure of successful abdominal wall reconstruction is a pain-free, complication-free, and durable hernia repair. Open techniques have generally lost favor, but they still have much to offer for patients with skin deficits and excess. The long-term complication rates for open hernia repairs is unknown. Electronic medical records now provide the ability to easily follow patients who have switched medical institutions. Using this tool, we followed a cohort of abdominal wall reconstruction patients who had an early high "success" rate.

Methods We performed a retrospective chart review of 101 patients who underwent open ventral hernia repair with a narrow well-fixed retrorectus uncoated polypropylene mesh by a single surgeon (GAD) between the years of 2010 and 2015. These patients were initially reported in a 2016 publication. Patients' post-operative follow-up by any medical provider assessing the abdominal region were studied up until August 2023. Patient demographics, operative reports, and postoperative course were re-reviewed.

Results A total of 101 patients underwent ventral hernia repair. Mean follow-up time was 7.68 years (range 1.8 – 13.0 years). There were no recurrent hernias across the studied time period and no instances of enterocutaneous fistulas. 15 patients (15%) had abdominal surgery after hernia repair unrelated to their original surgery and 5 patients (5%) reported chronic post-operative pain. 13 patients died in the follow-up period, all unrelated to the abdominal wall surgery.

Conclusion Open well-fixed narrow retrorectus mesh hernia repairs perform well in the long-term without fistulas, extrusions, and hernia recurrence.

Keywords mesh · hernia · retrorectus · open

Introduction

Over the last 3 decades, abdominal wall reconstruction (AWR) has moved from bridged mesh repairs to direct supported repairs where the rectus muscles are reapproximated in the midline and supported with an underlying mesh. In 2016, a consecutive series of over 100 midline abdominal hernia patients treated from 2010 to 2015 with limited skin flap elevation, placement of a narrow well-fixed mesh, and perforator preserving anterior components releases as needed were reported [1]. The surgical technique for these patients is different than commonly described retrorectus repairs, as it aims to use a narrow 7.5 cm wide mesh that is fixed with multiple transfascial sutures placed along the length of the rectus muscles. Surgeons performing the Rives-Stoppa repair typically use wide meshes that reach from semilunar line to semilunar line to improve mesh overlap with the abdominal wall and they often avoid suture fixation of the mesh to decrease postoperative pain [2, 3]. Use of a narrow well-fixed mesh may have certain advantages over the placement of large unfixed retrorectus meshes by limiting dissection, by decreasing the total amount of foreign material, by better distributing the initial forces on the hernia repair, and finally by ensuring that the mesh remains flat without wrinkles. This cohort of patients had a low

The senior author briefly describes a mesh suture that he uses for certain types of abdominal wall reconstructions. The senior author has intellectual property and ownership in MSI, the manufacturer of mesh suture.

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surgical site occurrence (SSO) rate and a hernia recurrence rate of 0% with a mean follow-up of 1 year of an in-person physical examination by the senior author. A criticism of this study was the short length of follow-up of 399 days for these patients and the unknown long term complication rates of extrusion, obstruction, fistula formation, and hernia recurrence.

With new electronic health information exchange (HIE) platforms allowing for sharing of records between disparate healthcare service providers, there is now the ability to have a more holistic, complete view of patients' postoperative outcomes. We hypothesized that additional long-term evaluation of the reported 2016 patient cohort employing the benefits of a more unified electronic medical record, could reveal new complications such as pain, fistulas, and hernias, or uncover other unexpected outcomes. Under this context, the present study was performed.

Methods

A consecutive series of isolated midline incisional hernias was collected and reported in 2016, and this series represents the identical patient cohort but with longer follow-up. All patients were treated with a narrow well-fixed midweight uncoated polypropylene mesh (PROLENE Soft Prolene Mesh; Ethicon, Somerville, NJ) as described below by a single surgeon (GAD) at Northwestern Memorial Hospital between the years of 2010 and 2015.

Surgical technique

Patients had a reconstruction of the entire linea alba with this open technique. A long incision is made from the xyphoid to near the symphysis pubis (Figs. 1–2). After freeing the bowel from the posterior aspect of the hernia sac and the abdominal wall, soft tissue flaps are created to expose 4 cm of unscarred anterior rectus fascia. Next, an assessment is made if an anterior components release is required to decrease tension at the midline. With the patient fully relaxed, if the surgeon is unable to manually approximate the medial border of the rectus muscles with a simple holding of the tissues between the thumb and index finger, then an anterior components release using lateral incisions and perforator preservation is performed [4]. An anterior components release done with lateral incisions to access the external oblique muscle and fascia can be done rapidly even in the presence of functioning ostomies and ostomy scars [5]. The retrorectus space is created from the xyphoid to the space of Retzius, and the posterior sheath is then closed with a running monofilament absorbable suture (Figs. 3–4). Specific to this operative technique, a narrow 7.5 cm wide mesh is used to reinforce the midline closure in a very specific manner (Figs. 4–5). The mesh is fixed to the undersurface of the rectus muscle for the length of the abdominal wall by multiple 0 polypropylene sutures. The suture passes through the anterior rectus fascia and then through the rectus muscle to then catch a few filaments of the macroporous polypropylene mesh. The suture is then passed back through the muscle and fascia to be tied on the anterior rectus fascia. The mesh is secured every 2–3 cm along its length with these U-shaped sutures to create a narrow well-fixed mesh. The sutures are snapped long and tied after all are placed. The surgeon avoids any intercostal nerves that are visible. Tying down the lateral sutures distributes the tension on the closure and brings the medial borders of the rectus muscle to the midline where they are then approximated with a running monofilament absorbable suture (Figs. 6–7). Excess skin is excised in a vertical direction and the skin is closed over drains. Drains are removed when less than 30 cc a day for two days. Antibiotics are discontinued within 24 h. This technique is unchanged from prior publications [6].

Fig. 1: 66-year old gentleman with an incisional hernia due to a midline extraction site after prostatectomy. The incision was placed in the center of rectus diastasis

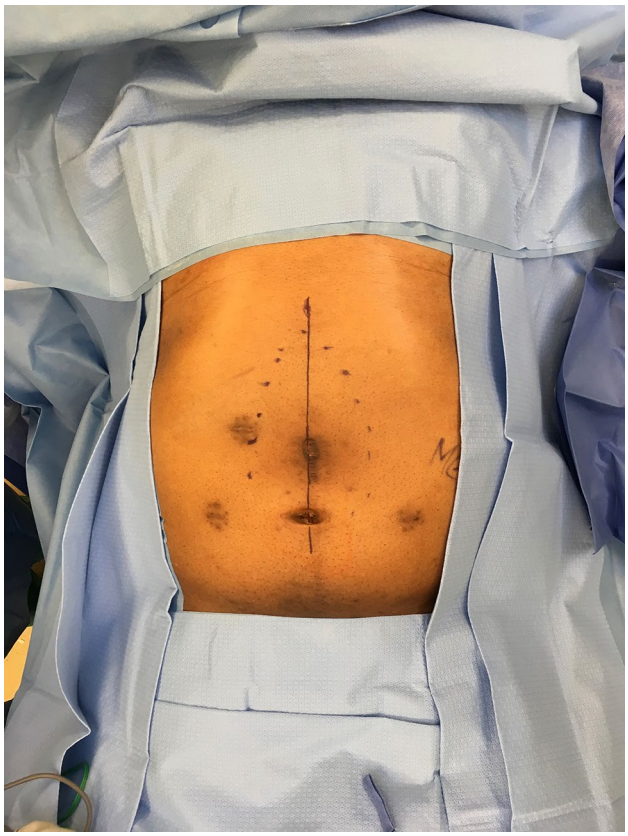

Fig. 2 Incision from the xyphoid through the umbilicus to approximately 3 cm below the umbilicus

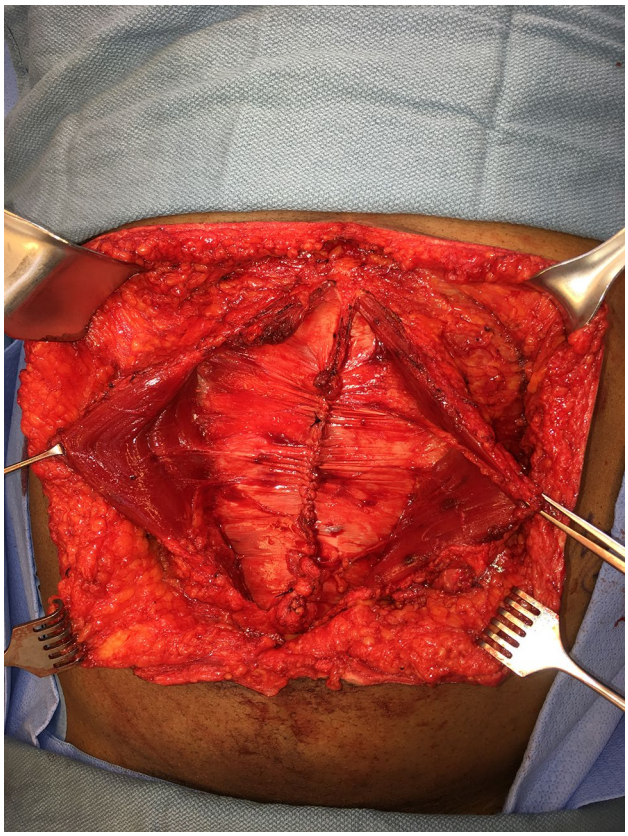

Fig. 3 After skin flap elevation to expose 4 cm of rectus abdominis fascia, the retrorectus space is created and the posterior sheath is closed with a running monofilament

Retrospective chart review

Ethics Committee approval was requested from Northwestern University to perform a retrospective chart review of qualifying patients. After institutional board approval was obtained, the electronic medical record (EPIC; Verona, WI) and specifically the "CareEverywhere" feature was queried for surgical and medical history. Patient follow-up was defined as a written comment on the abdominal wall by a physician, nurse, or nurse practitioner, and it was assumed for the purposes of this study that the presence of a hernia would elicit a positive notation on physical examination. If the abdominal wall was not specifically noted on physical examination or in other written comments, the visit was not scored as a post-operative follow-up visit. Any return to the operating room for abdominal surgery ended patient follow-up, and the operative report was evaluated for any notation of recurrent hernia. Abdominal CT scans were reviewed (when present) for abdominal wall integrity. Any report in Epic of a new hernia, recurrent hernia, or surgical repair of a hernia was specifically noted. The latest documented abdominal wall examination was used for final follow-up. CT scan results and/or abdominal surgery operative reports were used as confirmatory information in 21 patients. Secondary outcomes recorded included the development of chronic abdominal wall pain, extrusion, bowel obstruction, and development of enterocutaneous fistula. Patients were not contacted as a part of this retrospective study.

Results

Patient demographics and abdominal wall characteristics

The 101 patients represented were treated in an academic medical institution. Average age was 55.7, average BMI was 29.1, and 44% had recurrent hernias (Table 1). The majority (95%) of patients had Centers for Disease Control (CDC) class 1 clean wounds. 42 patients were Ventral Hernia Working Group grade 1, 40 grade 2, 17 grade 3, and 2 grade 4 [7]. For patients with preoperative CT scans, the average transverse fascial defect was 6.2 ± 3.6 cm. In some patients, the force required to close the abdominal wall was judged too great, and therefore anterior component releases using perforator preservation was applied in 28 patients. For these

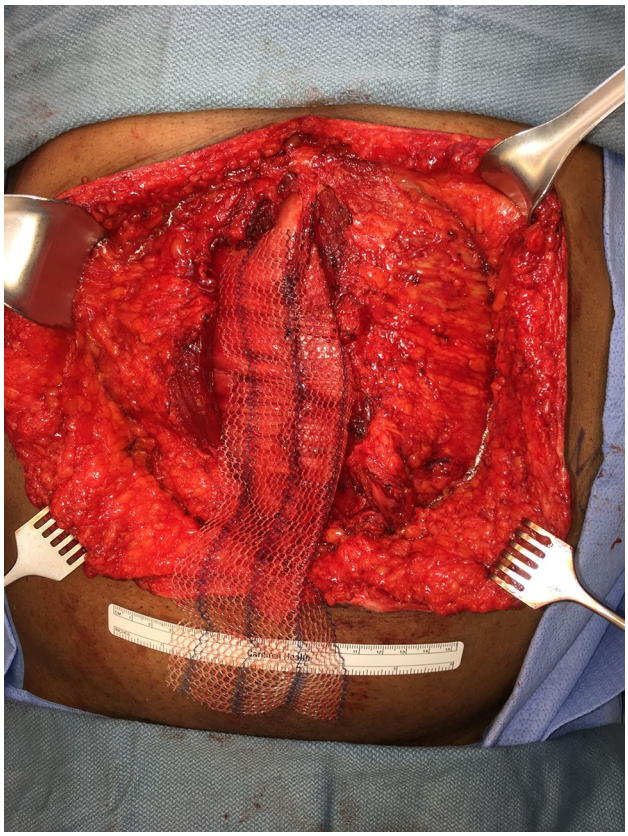

Fig. 4 A 7.5 cm wide uncoated midweight polypropylene mesh is placed in the retrorectus space

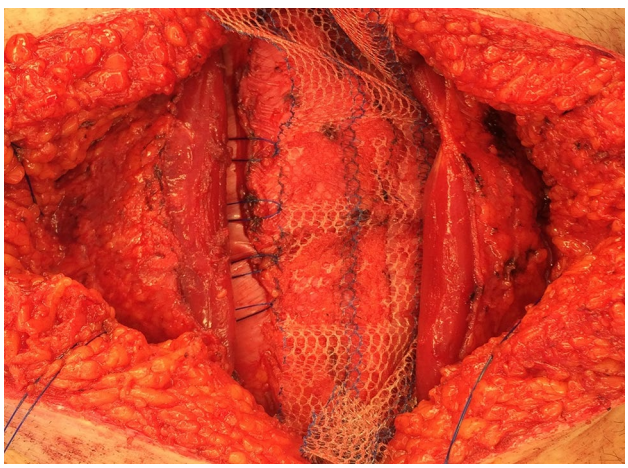

Fig. 5 Close-up image of transfascial 0-polypropylene suture with an entry point 4 cm from the medial border of the rectus muscle. The suture passes through the anterior rectus fascia and through the rectus muscle to then catch a few filaments of the macroporous polypropylene mesh. The suture is then passed back through the muscle and fascia to be tied on the anterior rectus fascia

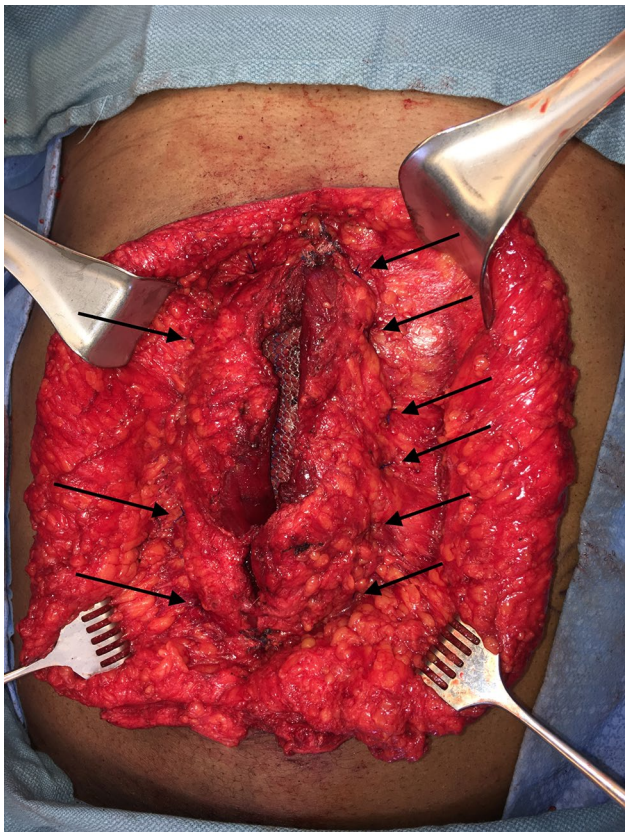

Fig. 6 Black arrows point to the 0-polypropylene knots tied and resting on the anterior rectus fascia 4 cm from the medial border of the rectus muscle. Tying the sutures forcefully brings the medial borders of the rectus muscle to the midline where the free margins can be approximated with minimal tension using a running suture

patients, the greatest separation of the medial borders of the rectus muscles was 7.9 ± 4 cm.

Early outcomes

At the time of surgery and as reported in the 2016 paper, patients did very well in terms of short-term outcomes. The study reported average operative time was 135 min. The SSO rate was 8% and surgical site infection rate was 3%. Five percent of patients were readmitted for any reason within the first 30 days, and only 1 patient had a return to the operating room within the first 30 days. The median number of postoperative visits in the first three months by the surgical team was two. Three patients did not achieve 3 month follow-up and were excluded from further analysis.

Late outcomes

Review of the electronic medical record increased from follow-up from 399 days in the original publication to 7.68 years for the 98 remaining patients (range 1.8

Fig. 7 Excess skin in removed in the midline, and the umbilical skin flaps are tacked back down to the abdominal wall. One drain is visible

Table 1 Baseline patient characteristics

Characteristic	Value
Age at time of surgery (mean +/-SD)	55.7 (12.0)
Men	34%
Women	67%
BMI (mean +/−SD)	29.1 (6.2)
Diabetes	10 (9.9%)
Current/recent smoker	7 (6.9%)
Recurrent hernia	44 (43.6%)
Prior prosthetic mesh repair	29 (28.7%)
Prior biologic mesh repair	10 (9.9%)
Prior components release	6 (5.9%)
Prior mesh or wound infection	15 (14.9%)

– 13.0 years). There were no recurrent hernias identified, and no patient returned to the operating room for a repeat hernia repair. Fifteen patients (15%) had abdominal surgery after their initial hernia repair unrelated to their original surgery that defined their final follow-up, and in no instance did the surgeon note a recurrent hernia. There were no late mesh infections, no extrusions, no bowel obstructions and no enterocutaneous fistulas. Five percent (n = 5) of patients reported chronic abdominal wall pain to their provider, but there were not any notations of severity. Thirteen patients died in the follow-up period, all unrelated to the abdominal wall surgery from malignancy or complications of chronic disease.

Images from two patients in the series are provided. Figure 8 demonstrates a two year follow up image of a patient with skin excess at the time of hernia repair. She was examined by the senior author 10 years after her hernia repair. Figure 9 illustrates a patient with skin deficit. His postoperative image was taken 2 years after surgery, and he was examined by the senior author 10 years after his hernia repair.

Discussion

While open techniques have generally lost favor for abdominal wall reconstruction to minimally invasive (MIS) robotic and laparoscopic procedures, they still have much to offer for patients with midline skin deficits and excess and need to remain in the armamentarium of all AWR surgeons. Patients with skin deficits typically demonstrate scars in the midline due to a stretched-out hernia sac. While an MIS procedure can fix the abdominal wall issue, the midline skin issues are ignored or else excised as a hybrid open/MIS procedure. In the opposite direction, numerous patients request skin removal and overall improvement of their abdominal wall contour, and these patients require skin removal. These patients are often referred for secondary skin removal surgery. MIS mesh placement teaching stresses wide meshes to distribute forces and limit recurrence, but this mesh strategy may not work well with open procedures where an emphasis on maintaining tissue vascularity to ensure mesh incorporation and healing is critical. There are secondary complications that can be related to the development of tissue planes from mid-axillary line to mid-axillary line. To this end, we reintroduce open hernia repair with a narrow well-fixed mesh. The technique and manner of open mesh placement is opposite that of MIS teaching and can treat patients with both midline skin deficits and excess.

Traditional hernia repair has been well-studied in terms of rates of early post-operative complications of surgical site occurrence (SSO) and late complications of hernia formation/mesh infection/mesh extrusion. SSOs include surgical site infections (SSIs), seromas, hematomas, and mesh infections [8]. They also include instances of delayed wound healing, enterocutaneous fistula, reoperation, or dehiscence. Cited rates of SSO can vary depending on the time point measured from the original procedure, and also on the technique utilized for the hernia repair. Case urgency, operative time, patient age, comorbidities, and BMI are other cited factors for variability in incidence of post-hernia SSOs.

Fig. 8 Preop (above) and postoperative images (below) of a patient with midline skin deficit closed with an open hernia repair utilizing a narrow well-fixed mesh. Image taken 5 years after hernia surgery, and she was examined by the senior author 10 years after repair

Meta-analyses looking at SSO rates across all ventral hernia repairs show pooled rates of 37.4% (range 30.0% to 45.8% across 91 studies) for bridged repair, 24.1% (range 12.5 to 26.2% across 319 studies) for primary fascial closure, and 26.6% (range 25.5% to 29.2% across 79 studies) for posterior component separation [9]. Such high rates of SSOs are problematic for patients who may then require a subsequent procedure. Our results of an 8% SSO rate was far below cited percentages for ventral hernia repair and may suggest benefits of the well-fixed, narrow midweight uncoated polypropylene mesh placed into a well vascularized operative field. The mesh is secured to the tissues, and it is a surgical adage that a "well-fixed implant does not become infected." We hypothesize that fixation of the polypropylene mesh to the undersurface of well vascularized muscle decreases micromotion and thereby serves to provide a solid platform upon which the soft tissues can heal. Recent meta-analyses focusing on understanding the rate of SSIs in VHR found that wound infections were reported in 17.7% of mesh repair patients [10]. These studies among traditional mesh repairs using large areas of mesh stand in contrast to the narrow mesh used in this study. By minimizing the total surface area of mesh placed, there is a lower likelihood of infection both from the decreased amounts foreign material as well as a more limited soft tissue elevations required for placement of narrow meshes that better serve to maintain tissue vascularity. Suture fixation of the mesh limits micromotion in comparison to an unfixed mesh and encourages rapid incorporation. Another surgical adage is that the more rapid the incorporation of the foreign material, the less likely an infection. Our 3% SSI rate is promising evidence to this claim, in comparison to the much higher rates of infection in traditional VHR with larger sheets of mesh. No mesh required removal, and we reemphasize that antibiotics were discontinued within 24 h of surgery for these patients.

The Rives-Stoppa repair for midline hernias has been taught as one of the "gold-standards" for incisional hernias and non-complicated ventral abdominal wall hernias in terms of hernia recurrence—the primary late outcome in ventral hernia repair [11, 12]. However, the standard Rives-Stoppa

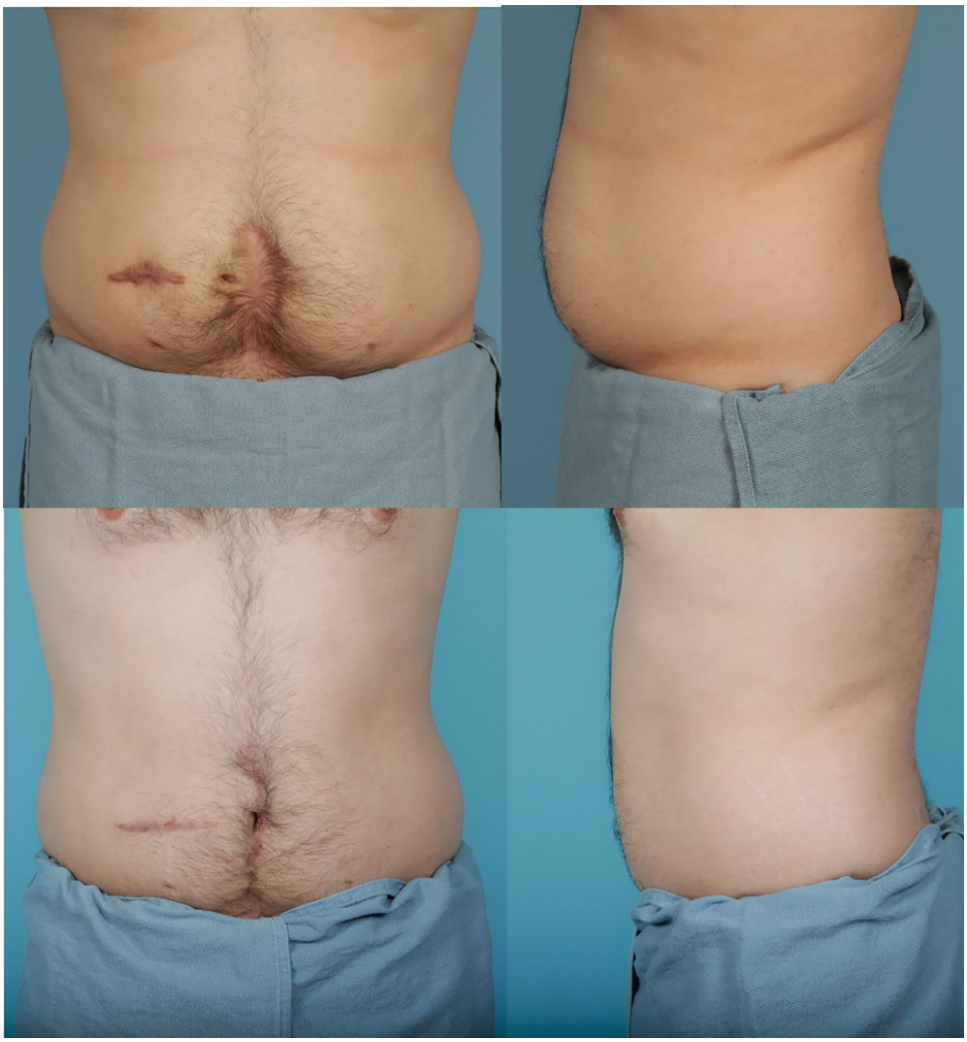

Fig. 9 Preop (above) and post-operative images (below) of a patient with midline skin deficit closed with an open hernia repair utilizing a narrow well-fixed mesh. Image taken 2 years after hernia surgery, and he was examined by the senior author 10 years after repair

repair simply fills the retromuscular space from semilunar line to semilunar line, with some surgeons using no fixation and others only suturing the cranial and caudal aspects of the mesh to avoid the mesh becoming bunched upon itself rather than to augment the initial hernia repair construct strength. The range of hernia recurrence rates for the Rives-Stoppa repair is quoted to be between 5% to 7.3% over time [13, 14]. Meta-analysis of Rives-Stoppa repairs found that pooled hernia recurrence was 3.2% after one year and 4.1% after 2 years, in studies representing over 12,000 patients [15]. For more substantial hernias, the transversus abdominis release (TAR) procedure uses an even wider mesh and achieves even greater overlap than the Rives-Stoppa repair. Despite the larger mesh, the reported TAR hernia recurrence is higher with studies showing recurrence rates from 3.7%[16] to 12.7%[17] to even 26% [18], measured over a year from initial procedure. An added potential injury to the tissues with TAR releases is damage to the semilunar line resulting in new lateral defects. Longitudinal studies looking at reoperation rates for hernia recurrences at 10 years after the index operation have shown the adjusted incidence is 16.1% across all hernia types and repair techniques [19]. It is essential in gauging the success of an abdominal wall repair to track outcomes across as many years as possible. While not yet reaching the 10 year average follow-up mark, our study did not identify any recurrent hernias.

Mesh choice is an important issue for any long-term analysis of outcomes. Slowly absorbing meshes such as those made of poly-4-hydroxy butyrate are touted to gradually transfer load to native tissues, thereby achieving a lasting abdominal wall closure without the risks of permanent meshes. A long-term study documented a 22% recurrence rate at 5 year follow-up for 54 patients who reached their final follow-up exam [20], while another study documented a 20% recurrence rate for the 43 patients also with 5 years of follow-up [21]. It has been argued that the foreign body reaction disappears and scar remodels and potentially weakens with the absorption of absorbable materials [22, 23]. We hypothesize that the permanent polypropylene filaments and the lasting foreign body reaction are critical for a durable

midline repair seen for the patients in this report. Despite the permanent polypropylene mesh used in this series, none of the patients had the other feared late complications of bowel fistula formation or mesh extrusion. This is attributed to the overall limitation of mesh use and the multiple suture fixation points that achieve a flat mesh without wrinkles that could cause a pressure sore into the bowel or out the skin over time.

Midline skin deficits are addressed by keeping the majority of the skin and soft tissues still attached to the anterior rectus fascia. Approximation of the rectus muscles with the narrow mesh carries the overlying skin with it to the midline, solving the majority of midline skin deficits. When a component release is performed, lateral incisions maintain skin vascularity. Clinically, the 4 cm of skin elevation off of the medical border of the rectus muscles does not cause any skin necrosis, but there is a dead space that requires management with one or two subcutaneous drains. Aesthetics are important for any hernia repair for quality-of-life outcomes as was brought up for patients with midline skin excess. The ability to repair the abdominal wall and to simultaneously remove redundant skin are central to the performance and low complication rates of this procedure, and obviate the need for a second separate "cosmetic" procedure. Central skin removal decreases dead space, removes less well vascularized skin and hernia sac, excises old scar, and permits the creation of a neo-umbilicus [24] all at the cost of a long midline incision. The dependability of the procedure permits the use of a well-fixed retrorectus mesh for the repair of severe rectus diastasis with simultaneous abdominoplasty [10, 25, 26]. MIS hernia repairs are not designed to bring good skin to the midline, nor to remove redundant skin and subcutaneous tissues.

An important co-consideration in studying long term outcomes is postoperative pain. Complex hernia repairs using traditional techniques such as the Rives-Stoppa procedure are associated with a high degree of postoperative pain extending beyond one year. In a well-cited study of 254 Rives-Stoppa patients with a mean follow-up time of 70 months (5.83 years), "27% of the respondents reported having intermittent abdominal wall pain and rated their worst pain during the entire follow-up period since discharge at a mean score of 4.3 ± 0.3 on the standard 0 to 10 pain scale" [27]. Pain outcomes in this cohort of patients was extensively analyzed in the prior publication using the Patient-Reported Outcomes Measurement System (PROMIS). [1] Over time with increased follow-up, five percent ($n = 5$) of patients reported chronic abdominal wall pain of any severity. In this series, the transfascial sutures placed to fix the mesh did not seem to be long-term pain generators.

All studies have weaknesses, and a primary shortcoming of this report is that it is a single surgeon series without a comparison group. However, it was felt that the positive outcomes for these patients were interesting and warranted presentation. Our longitudinal results relied on utilizing the capabilities provided by cross-network electronic health records as opposed to a visit to the original surgeon, and this can be considered a significant weakness of this analysis. The electronic health record has become valuable to hernia outcome studies with the relatively new unified health networks that are only improving over time [28, 29]. Patients that had a significant hernia occurrence surely would have shown this to their caregiver and possibly even returned to the operating room for a repair. That was not the case for these patients who had a benign physical examination of their abdomen, a negative abdominal CT scan, or an operative report that did not document any hernia recurrence in order to quality for extended follow-up. A limitation of the study is the absence of engagement with the patient to better understand qualitative outcomes of appearance and function.

This series represents the treatment of relatively straightforward mid-sized clean hernias, and therefore excluded the most complex patients where complication rates may be significant higher. Indeed, patient selection for a procedure is critical for matching the patient to a surgical technique. Currently, a well-fixed retrorectus mesh is reserved for high-demand patients with clean midline defects and a normally compliant abdomen with a separation of the medial borders of the rectus muscle in the range of 4 to 12 cm. For clean-contaminated and contaminated procedures where there is a desire to avoid opening tissue planes, a mesh suture is used (Duramesh Mesh Suture, MSI, Chicago IL) [30]. Patients with midline hernias less than 4 cm wide receive a choice of a retrorectus mesh vs a mesh suture. In the patients with wider hernias greater than 12–14 cm where it is difficult to reliably approximate the posterior sheath despite an anterior components release, patients are pre-treated with botulinum toxin before their anterior components release and receive a mesh suture closure [31]. Outcome studies for mesh suture patients is ongoing.

Conclusion

Our results, utilizing the capabilities provided by cross-network electronic health records, show that the open placement of a well-fixed retrorectus uncoated polypropylene mesh, had excellent outcomes free of recurrent hernia formation, extrusion, and fistula formation with an average of 7.68 years postoperatively.

Funding This study received no funding from any sources.

Declarations

Conflict of interest Dr Gregory Dumanian briefly describes a mesh suture that he uses for certain types of abdominal wall reconstructions. The senior author has intellectual property and ownership in the manufacturer MSI of mesh suture. Otherwise, the senior author has no further financial disclosures.

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