Title
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Journal
Clinics in Colon and Rectal Surgery, 27(04)

ISSN
1531-0043

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Publication Date
2014-12-01

DOI
10.1055/s-0034-1394088

Peer reviewed

Incisional Reinforcement in High-Risk Patients

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Clin Colon Rectal Surg 2014;27:149–155.

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Abstract

Hernia formation after surgical procedures continues to be an important cause of surgical morbidity. Incisional reinforcement at the time of the initial operation has been used in some patient populations to reduce the risk of subsequent hernia formation. In this article, reinforcement techniques in different surgical wounds are examined to identify situations in which hernia formation may be prevented. Mesh use for midline closure, pelvic floor reconstruction, and stoma site reinforcement is discussed. Additionally, the use of retention sutures, closure of the open abdomen, and reinforcement after component separation are examined using current literature. Although existing studies do not support the routine use of mesh reinforcement for all surgical incisions, certain patient populations appear to benefit from reinforcement with lower rates of subsequent hernia formation. The identification and characterization of these groups will guide the future use of mesh reinforcement in surgical incisions.

Keywords

- incisional reinforcement
- mesh reinforcement
- wound closure
- incisional hernia

CME Objectives:

- Review current literature on incisional reinforcement
- Examine the use of biologic materials in wound closure
- Review closure options for open abdomens and complex hernias

The prevention of wound dehiscence and incisional hernia formation has long been an area of challenge to general surgeons and surgical specialists. Using a mesh prosthesis to strengthen a surgical repair was first attempted at the end of the 19th century.[1] Surgeon Oscar Witzel used handmade silver wires interwoven in a filigree pattern and implanted them as a prosthetic mesh.[2] Although initial results seemed promising, the silver mesh fell out of favor in the late 1950s due to patient discomfort, seroma formation, sinus tract formation, and the development of new synthetic materials.[3] Polypropylene was introduced in 1954 by Nobel Prize winner Giulio Natta and Karl Ziegler, and became widely adopted as the material of choice for hernia repair.

Rising costs of health care worldwide have resulted in a great impetus to find ways of preventing postoperative hernia formation. Although advanced materials such as biologics are expensive, the potential savings gathered by a decreased rate of hernia recurrence are significant. Furthermore, being able to prevent the morbidity and mortality associated with wound dehiscence and hernia formation offers unmistakable rewards. The objective of this article is to review current indications, evidence, and outcomes of incisional reinforcement in high-risk patients with midline laparotomy, perineal incisions, an open abdomen, component separation, and ostomy takedown procedures.

Midline Laparotomy Reinforcement and Modern Alternatives to "Retention Sutures"

Entrance into the peritoneal cavity may be achieved through a multitude of surgical incisions. A vertical midline incision through the linea alba is commonly used to provide exposure and allow visualization of all portions of the abdominal cavity. However, one of the limitations of this incision is that it carries a higher risk of hernia formation. Incisional hernias are estimated to occur in 5 to 15% of patients at 1 year.[4–6] In a long-term study by Mudge and Hughes,[7] 11% of patients had developed a hernia 10 years after their initial operation. This number can be significantly larger in high-risk patients such as the morbidly obese, rising to an incisional hernia rate of between 26 and 39% at 1 year.[8] Overall risk of hernia formation should be evaluated on a case-to-case basis, as each

Issue Theme Biologics in Colon and Rectal Surgery; Guest Editor: Eric K. Johnson, MD, FACS, FASCRS

DOI http://dx.doi.org/10.1055/s-0034-1394088.
ISSN 1531-0043.

patient can have different factors predisposing them to this condition. Risk factors such as age, nutrition, body mass index, comorbidities, the presence of infection, and tobacco use should all be taken into account during surgical planning for a patient's method of abdominal closure.

Currently, the most widely used technique for closure of the midline laparotomy incision is a continuous looped absorbable suture.[9,10] Even with precise surgical technique and the optimal suture length to incision length ratio, the overall incidence of incisional hernia following laparotomy is reported to be between 11 and 23%.[11] Due to the high rate of hernia formation, prophylactic use of mesh has been considered to reinforce these defects. Both biologic and synthetic mesh have been used and shown to lower incidence of hernia formation in high-risk patients.[11–15] However, there are limited data supporting the use of reinforcement in routine midline laparotomies.[16] The randomized controlled trials that have been published to date are small with relatively short follow-up periods.[13–15] In 2011, Llaguna et al[11] analyzed 134 patients who underwent open Roux-en-Y gastric bypass to evaluate if prophylactic use of a biologic mesh protects against the development of incisional hernia for high-risk patients. In this randomized controlled trial, the overall incidence of incisional hernia was 11.3%, with significantly lower incidence in the mesh group compared with the nonmesh group (2.3 vs. 17.7%). A few older randomized controlled studies by Strzelczyk et al[17] and Gutiérrez de la Peña et al[12] similarly found prophylactic polypropylene mesh placement to be protective against incisional hernia development. While long-term outcomes of prophylactic mesh use are still unclear, mesh repair of incisional hernias after laparotomy has been found to be safe and effective, particularly when used as an underlay reinforcement.[18,19]

In 2010, the Ventral Hernia Working Group (VHWG) proposed a grading system to better assess each patient's risk for surgical-site occurrence or hernia occurrence. With regard to the choice of repair material, the authors of this article emphasized the selection of biologic reinforcement for increasing amounts of contamination in ventral hernias.[20] This recommendation has been adopted and promoted by many surgeons; however, there are no randomized prospective studies comparing the clinical outcomes of biologic versus nonbiologic grafts in hernia repair. A recent systematic review and meta-analysis by Darehzereshki and colleagues[21] concluded that the use of biologic mesh for ventral hernia repair results in less surgical site infections but similar recurrence rates compared with nonbiologic mesh. Another recent study by Souza and Dumanian[22] challenged the recommendation by the VHWG, stating that the use of uncoated polypropylene mesh to reinforce midline ventral hernia repairs was not associated with increased rates of infection, fistula formation, or clinically significant adhesions. It is important to note that the cost of biologic mesh is significantly higher than that of synthetic materials. In 2012, Reynolds and colleagues published an analysis of the financial implications of ventral hernia repair.[23] In their review of cost data on 415 consecutive patients undergoing open ventral hernia repair, the median direct cost for cases performed without mesh was $5,432, median direct cost for repairs using synthetic mesh was $7,590, and median direct cost for repair with biologic mesh was $16,970. Further studies are necessary to determine if routine use of these materials for reinforcement will prove to be cost-effective through improvements in long-term outcomes.

Despite many advances in surgical technology, fascial dehiscence still ranges from 0.2 to 6% with mortality ranging from 9 to 44%.[24,25] Wound infection plays one of the largest roles in the breakdown of a fascial closure.[26] There is little evidence supporting the routine use of retention sutures in the general patient population; however, they may be of use in high-risk groups.[27] A recent study by Khorgami et al examined 300 high-risk patients undergoing midline laparotomy. Closure was randomized to continuous running looped suture versus continuous running looped suture with added retention sutures. They found a higher rate of dehiscence (13.5 vs. 4.1%) and reoperation for dehiscence (13.5 vs. 3.4%) in the group without retention sutures.[27] Each patient had at least two of the following risk factors: poor nutritional status, emergent surgery, intra-abdominal infection, advanced malignancy, use of steroids within the last 12 months, uremia, hemodynamic instability, anemia, abdominal distension such as due to ascites, chronic pulmonary disease, age greater than 60 years, diabetes, or jaundice.[27] Retention sutures are still useful in certain circumstances and their use should be assessed on an individual patient basis. Disadvantages to the use of retention sutures are unsightly scarring that may result from their use, as well as added postoperative pain. Perhaps this could be avoided by replacing retention sutures with prophylactic mesh reinforcement, although no studies have been performed analyzing outcomes of this technique in conjunction with mesh placement or compared with mesh placement for laparotomy closure or hernia repair.

Reinforcement of a midline incision may be advantageous in some high-risk patients, but this specific population has yet to be described. Studies have described methods that are useful in predicting those that will develop an incisional hernia, but none have been effective in predicting hernia based on information known at the time of incisional closure.[28] This limits our ability to employ the most cost-effective use of mesh prophylaxis. Routine mesh reinforcement does not appear to have a defined role at this time, but appears to have the potential to decrease recurrence rates. The choice of mesh must take into account the contamination of the surgical field and the patient's risk factors that would predispose to poor wound healing.

Abdominoperineal Resection Incision and Pelvic Floor Reinforcement

Abdominoperineal resection (APR) allows for treatment of cancers of the anus and low rectum. A permanent end colostomy is created after resection of the anal complex and closure of the perineum. The perineal wound has been a source of frequent complication since the operation was first performed in 1908.[29] Multiple techniques have been applied with varying success. Perineal wound complications are estimated to occur in up to 66% of cases.[30,31]

Myocutaneous flaps have been used as an alternative to primary closure of the perineal wound after APR. This technique transfers healthy tissue from the abdominal wall into the pelvic cavity. In 1984, Shukla and Hughes described using a vertical rectus abdominus myocutaneous flap for perineal closure in three patients.[32] Several decades later in 2010, Shukla and Tewari reviewed 22 studies describing the use of a rectus flap for perineal cancer resection and showed improved morbidity.[30] The gracilis flap was also used as an alternative to primary closure.[33,34] Although it appears to have lower morbidity, one drawback of the gracilis flap is the limited amount of tissue which can be provided for large defects in the perineum. Tan et al[35] have also proposed a lower gluteal muscle flap to overcome this disadvantage; initial results have been favorable in small series.

The rate of wound complications can double when primary closure is performed in patients undergoing neoadjuvant radiation therapy.[36] Myocutaneous flap coverage has been shown to significantly decrease wound complications in these patients.[31,37–39] However, these improved outcomes come at a cost. The majority of myocutaneous flap procedures are performed by plastic surgeons leading to increased expense and a longer operative time due to a larger dissection.[40] Christensen et al[41] also noted a longer mean hospital stay after flap procedures compared with a perineal mesh repair (14 vs. 9 days).

APR has historically been associated with poor oncological outcomes, specifically high local recurrence rates of up to 30%, despite aggressive adjuvant therapy.[42] These outcomes may be due to the technical challenges of the operation or aggressive tumor characteristics that require APR. Regardless, some surgeons have adopted a more cylindrical dissection or extra levator abdominoperineal excision (ELAPE) as a means of ensuring negative circumferential margins. While this appears to have improved oncologic outcomes, these surgical techniques also result in the creation of a larger pelvic defect. Reconstruction of the pelvic floor with a biologic or synthetic mesh can be accomplished by attaching the mesh to the origin of the levator muscles, which are removed during an ELAPE.[43] This allows for reinforcement of the pelvis underneath the ischiorectal fat and perineal skin (►**Fig. 1**). Due to the contamination inherently present in the surgical field, use of synthetic mesh has rarely been described.[44] However, multiple biologic meshes have been studied and appear to have similar outcomes to flap reconstruction.[40,41,45] A systematic review performed in 2011 by Foster et al[45] examined 11 cohorts with a pooled analysis of 255 patients undergoing flap repair and 85 patients undergoing biologic mesh repair. There was no significant difference in perineal complications between the two groups. Marshall et al[43] similarly reviewed nine articles examining the use of biologic mesh after ELAPE and concluded that outcomes of reconstruction with biologics is comparable to that of myocutaneous flaps. There are no current studies analyzing outcomes between different types of biologic mesh.

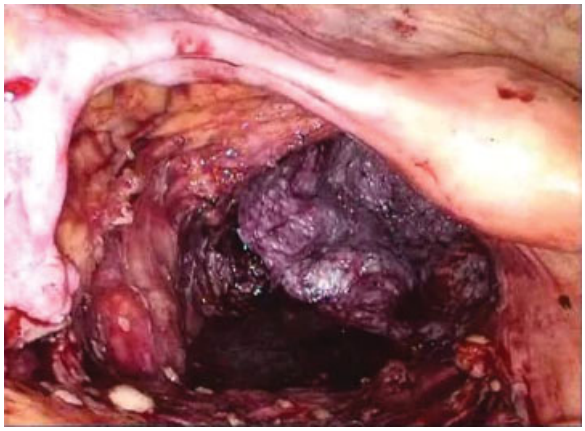

Fig. 1 Reinforcement of the pelvic floor with mesh after abdominal perineal resection.

Perineal wound closure after APR continues to be an evolving field. Primary closure in a nonradiated patient is reasonable; however, advanced closure techniques may allow for improved outcomes overall. Myocutaneous flaps are a surgical option but can lead to longer operative times, increased cost, and a longer hospital stay.[41] Recent literature has shown biologic mesh reinforcement to be a viable closure method.[45] Additional research is necessary to evaluate short- and long-term outcomes of these approaches.

Dealing with the Open Abdomen

An open abdomen presents a complex surgical wound that must be managed until the patient's status improves. The open abdomen can result from a variety of intra-abdominal catastrophes in which a patient's physiological status or underlying disease process does not allow for a complete fascial closure at the time of initial operation. Many techniques have been applied throughout surgical history to treat this condition including vacuum-assisted devices, mesh implantation, Bogota bags, Wittmann patch, abdominal packing, and dynamic retention sutures.[46] Rates of mortality and morbidity following this condition are often high due to the patient's underlying status as well as the typically long length of hospital stay. Complication rates can range from 10 to 52% depending on the method used and the etiology of the illness.[47] Morbidities such as enteroatmospheric fistula (1–41%), abscess (2–21%), or ventral hernia development (32–100%) can be seen.[47]

Mesh closure of an open abdomen is usually accomplished by bridging a biologic or synthetic mesh across the fascial defect. This prosthetic may provide the only barrier protecting the viscera from the external environment. Mesh cinching or further coverage with a split-thickness skin graft can be considered depending on the individual circumstances in an attempt to maximize coverage of the defect.[48] Some studies have shown higher fistula formation with synthetic meshes.[49,50] For example, Fansler et al[50] showed fistula rates of 40 to 50% after synthetic mesh use in midline wounds that were allowed to close by secondary intention or split-thickness skin grafting. For this reason, biologic meshes have become more widely used for closure of midline defects after laparotomy.[46]

Although placement of a bridging mesh may allow for temporary abdominal closure, many of these patients (21–37%) will

still require definitive closure in the future.[48] Quyn et al[46] reported a closure rate of only 35% in a meta-analysis of 106 articles describing management of the open abdomen. The highest closure rates described in the literature have been reported with the Wittmann patch, dynamic retention sutures, and vacuum therapy.[46] As expected, methods that result in higher rates of fascial closure were associated with lower rates of postoperative morbidity and mortality.[47,51] It is important to note that no single closure method has been shown to be ideal and further research is necessary to determine the long-term role of prosthetic compared with biologic mesh use. Therefore, individual surgeon experience should guide decision making and influence the chosen technique that is safe and feasible in these complex patients.

Component Separation Reinforcement

Mesh has been used in the reinforcement of ventral hernias since the early 1990s.[52] The concept of prosthetic reinforcement developed because of unacceptable high recurrence rates following traditional methods of hernia repair.[53,54] Studies with long-term follow-up reported recurrence rates greater than 50% following primary open suture repair with fascial reapproximation.[55–57] After development of synthetic mesh, techniques of tension-free mesh reinforcement rapidly gained widespread acceptance for hernia repair. However, the ideal method of mesh implantation is still under debate and long-term recurrence rates have been reported to be as high as 32%.[18,58,59] In 1990, Ramirez et al[60] described the technique of medial fascial advancement to assist with midline closure. In this article, the posterior rectus sheath was first released and then, if necessary, the external oblique was secondarily released. Recurrence rates after a component separation have been reported to range between 10 and 22%.[61–64] Obesity, age, male gender, postoperative seroma, and preoperative infection have all been identified as risk factors for hernia recurrences.[65]

Several studies have examined the use of biologic and synthetic mesh during component separation with varying results.[62,63,65,66] Lowe et al examined 30 patients undergoing component separation for closure of complex abdominal wall defects; however, 23% of patients did not have complete fascial reapproximation.[64] In these circumstances, mesh can be used to bridge the remaining defect present after release of the components. However, studies have shown that reapproximation of the linea alba leads to lower rates of recurrence.[60,64,67] Care must be taken if biologic mesh is used for this purpose, as breakdown over time may result in high hernia recurrence rates, reportedly up to 80%.[67]

A variety of techniques have been described for medial fascial advancement. These can broadly be divided into anterior and posterior approaches to component separation. A review of the literature and surgical techniques recently published by Pauli and Rosen described multiple options for component separation with mesh reinforcement.[68] The mesh can be placed as an underlay within the peritoneal cavity, sublay within the retrorectus space (►**Fig. 2**), or an onlay over the closed midline repair. Regardless of the implant location or

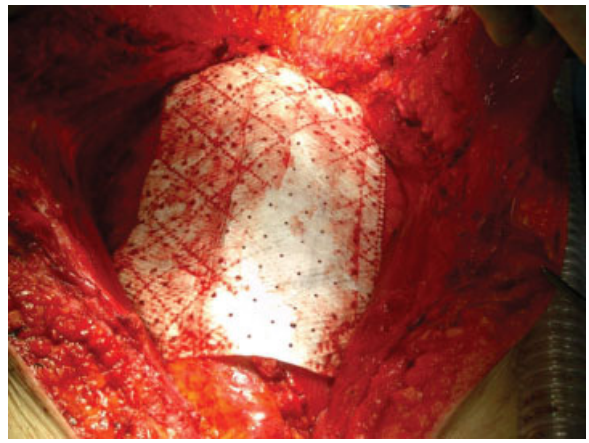

Fig. 2 Mesh reinforcement after posterior component separation. The mesh is placed as a sublay in the retrorectal space.

type, the authors recommend securing the mesh with slowly absorbing monofilament suture and placing it under physiologic tension. Drains are also generally placed above the mesh regardless of implant location. Recurrence rates after anterior component separation were reported to range between 3 and 32% and recurrence rates after posterior component separation ranged between 1.1 and 7.3%.[68] Another recent article by Alicuben and Demeester[69] described their experience and outcomes of biologic onlay mesh reinforcement for ventral hernia repair. The majority (73%) of patients also underwent a bilateral external oblique component separation. Median hospital length of stay was 7 days and intervention for seroma formation occurred in 27% of patients. Although the series is small with a total of 22 patients, there was only one hernia recurrence at median follow-up of 7 months. The recurrence occurred in a patient who was bridged with mesh as a staged procedure for loss of domain.

As with all prosthetic devices, the risk of infectious complications and erosion must always be considered. No definitive evidence has shown a specific mesh product to be superior and factors such as cost, recurrence, and the presence of infection can help guide the choice of mesh used. Familiarity with multiple reinforcement techniques allows for adaptability during complex abdominal wall reconstruction.

Ostomy Takedown Site Reinforcement

Ostomy reversal can provide patients with improved quality of life but carries considerable potential for postoperative complications. Hernia formation at a previous ostomy site occurs in up to 30% of patients and half of these patients will require surgical intervention.[70] Subsequent operations for repair of a ventral hernia carry further potential for morbidity. The current standard for stoma reversal is to primarily close the fascial defect present at an ostomy site. If a hernia occurs, it is electively repaired in a standard fashion using laparoscopic or open techniques.

Slater et al[71] performed a systematic review of ventral hernia repairs with biologic mesh placement in 2013 and

reported postoperative infection and overall rate of surgical morbidity as key factors in hernia recurrence. A significant difference in recurrence was seen between clean and clean-contaminated cases (2.9%) versus contaminated and dirty cases (23.1%). These infectious complications must be taken into consideration when placing mesh at an ostomy site. A large prospective study performed by Helgstrand et al[72] in 2013 examined a Danish database of elective incisional hernia repairs. Rates of 30-day readmission and 30-day reoperation were found to be 13.3 and 2.2%, respectively. New techniques to decrease the rate of stoma site hernia formation would help prevent additional perioperative morbidity associated with reoperation and readmission.

Prophylactic mesh placement at the time of stoma closure has been described as a potential method of decreasing hernia formation. However, ostomy site closure is slightly complicated by the presence of contamination from intestinal flora at the surgical site. No large scale studies have been performed examining outcomes of mesh placement at the time of stoma closure. Synthetic and biologic meshes have been examined for other indications, such as parastomal hernia repair, with favorable results.[73,74] Liu et al described the use of a synthetic onlay mesh placed during stoma closure. No difference in overall complication rates was seen when compared with conventional ostomy closure and no mesh infections were reported.[75] Hernias were seen in 36.1% of the stomas closed without mesh and only 6.4% of the stomas closed with mesh. A slightly modified approach was taken by van Barneveld et al who reported a decrease in hernia formation after intraperitoneal mesh placement at the time of stoma creation.[76] This mesh was then reapproximated during ostomy reversal. No hernias were seen postoperatively at a median follow-up of 26 months.

Ostomy site closure carries a significant risk of hernia formation leading to long-term morbidity. In some limited studies, mesh reinforcement has been shown to decrease hernia recurrence at these sites without an increase in infectious complications. However, mesh choice has not been standardized and further investigation is needed to determine optimal technique and prosthetic material. Additional research is also necessary to determine perioperative and long-term outcomes of routine stoma site reinforcement during ostomy takedown.

Conclusion

A multitude of different techniques have been described to close and reinforce surgical incisions. Primary suture closure of a wound is no longer the only option. New materials and methods have altered the standard approach to treatment of abdominal incisions or complex ventral hernias, and this continues to evolve with scientific advancements. Although mesh reinforcement is not the standard of care for the majority of surgical incisions, emerging data show that it may have long-term benefits in hernia formation and recurrence. As new materials emerge and production cost is reduced, the role of mesh in incisional reinforcement will likely continue to expand.

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