

# Novel Approach for Umbilical Hernia Repair Using Mesh Strips

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**Background:** Umbilical hernia repair is a common surgical procedure without a universally accepted means of repair. We introduce a novel surgical technique for open primary umbilical hernia repair, using strips of polypropylene mesh as sutures to achieve a repair.

**Methods:** Two-centimeter-wide strips of macroporous polypropylene mesh were passed through the abdominal wall and tied as simple interrupted sutures to achieve umbilical hernia repair. A retrospective review of all elective umbilical hernia repairs performed by a single surgeon using the mesh strip technique between 2016 and 2021 was conducted, and patient-reported outcomes were assessed via a telephonic survey.

**Results:** Thirty-three patients underwent an elective, open mesh strip repair of a primary umbilical hernia and met criteria for inclusion in the study. Of these patients, 60% responded to a patient-reported outcomes telephone survey. Ninety percent of survey responders reported a pain score of 0 of 10. Additionally, 90% reported being unable to feel or palpate the knot, and 80% reported an improvement in quality of life. Mean follow-up at 3 years revealed one recurrence in the setting of ascites, yielding a recurrence rate of 3%.

**Conclusion:** Primary mesh strip repair of umbilical hernias combines the simplicity of suture repair with the advantageous force distribution properties of mesh, and constitutes a safe, efficient, and effective method of repair with a low recurrence rate at long-term follow-up that is comparable to planar mesh repair. (*Plast Reconstr Surg Glob Open* 2023; 11:e4947; doi: [10.1097/GOX.0000000000004947](https://doi.org/10.1097/GOX.0000000000004947); Published online 25 April 2023.)

## INTRODUCTION

Umbilical hernias are the most common type of primary ventral hernia,<sup>1</sup> and are defined as a midline abdominal wall defect located in the center of the umbilical ring.<sup>2</sup> Asymptomatic umbilical hernias may be present in up to 25% of the population.<sup>3</sup> When symptomatic, they can significantly affect an individual's quality of life, causing pain, bowel obstruction, functional impairment, and a cosmetically unacceptable bulge. Surgical repair of umbilical hernias accounts for nearly 175,000 procedures annually in the United States.<sup>4,5</sup> However, there is a lack of consensus regarding the

optimal repair technique for this frequently performed surgical procedure.<sup>2</sup>

The primary goal of umbilical hernia repair is to achieve a durable closure of the abdominal fascia, while minimizing pain and risk of complications such as surgical site occurrence (SSO), bowel injury, early or late infections, and hernia recurrence. A variety of surgical techniques have been described, including simple suture repair, open repair with mesh, open repair with prefabricated mesh "patches," laparoscopic repair, and even robotic repair.<sup>6</sup> Simple suture repair of umbilical hernias suffers from a risk of recurrence due to the problem of suture pull-through, in which the forces at the suture-tissue interface (STI) overcome the forces holding the tissues together. This results in "cheesewiring" as the suture pulls through the tissue, leading to failure of the repair.<sup>7</sup> A recent large cohort study of small umbilical and epigastric hernias (<2 cm) reported

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a 21% recurrence rate for suture repair at 55-months follow-up.<sup>8</sup>

There is consensus that the use of planar meshes for the treatment of umbilical hernias decreases the recurrence rate.<sup>5</sup> The same large cohort study demonstrated a 10% long-term recurrence rate for umbilical hernia repair with mesh reinforcement.<sup>8</sup> However, small umbilical hernias present technical challenges for the placement of a planar mesh. Compared with suture repair, open mesh repairs require wider dissection of soft tissues and, occasionally, even enlargement of the fascial defect simply to accommodate and fixate a planar mesh. Conversely, minimally invasive laparoscopic procedures are not without risk of bowel perforation, adhesion formation, and additional cost.<sup>9</sup> One prefabricated mesh patch used commonly for umbilical hernia repair is currently the target of a large class-action lawsuit.<sup>10</sup> These are some of the reasons for which surgeons continue to opt for simple suture repair of small umbilical hernias despite the lower recurrence rates with the use of mesh.<sup>11</sup>

We present a novel technique for the open repair of small umbilical hernias using strips of light-weight macroporous polypropylene mesh passed through the abdominal wall and tied like sutures. This mesh strip repair aims to combine the simplicity of sutures with the advantageous force distribution properties of mesh to achieve durable umbilical hernia repair.

## METHODS

### Inclusion and Exclusion Criteria

The decision to perform a mesh strip repair was made by the senior surgeon (G.A.D.) based on an expected high risk of hernia recurrence with suture closure alone. Patients were educated preoperatively about the risks and benefits of sutures, meshes, and mesh strips used as sutures. Inclusion criteria consisted of patients 18 years or older with a symptomatic primary umbilical hernia less than 3 cm in diameter repaired with a mesh strip technique. Exclusion criteria consisted of umbilical hernias greater than 3 cm in diameter, any use of a planar mesh, pregnancy, significant rectus diastasis, or umbilical hernias repaired in combination with or as part of a more extensive abdominal surgery such as a rectus diastasis plication. These patients were excluded as our preferred technique for repair of larger hernias or for repair of significant rectus diastasis includes placement of a well-fixed planar mesh in the retro-rectus plane.<sup>12,13</sup> Combination procedures where a separate operative site other than the abdomen was involved were not excluded.

### Mesh Strip Surgical Technique

The patient is positioned supine, placed under monitored care anesthesia, and prepped and draped in the usual fashion. A curved, infra-umbilical incision is designed, and the skin and subcutaneous tissues are widely infiltrated with a solution containing 1% lidocaine and 1:200,000 epinephrine (Fig. 1). Incision is made sharply with a number 15 blade, and the skin and subcutaneous

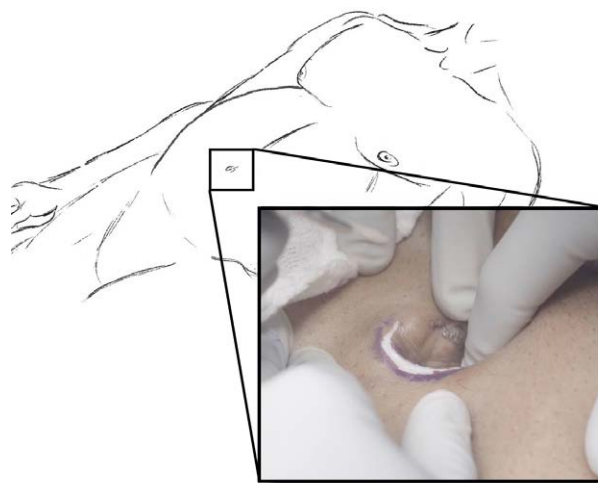
## Takeaways

**Question:** Does a novel umbilical hernia repair technique using strips of polypropylene mesh as sutures result in a safe and durable solution with high patient satisfaction?

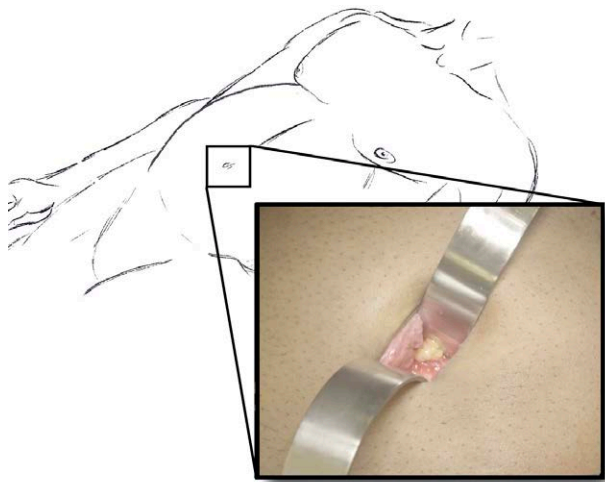
**Findings:** The 3-year hernia recurrence rate was 3%, and the surgical site infection rate was also 3%. Patient-reported outcome survey data indicated high patient satisfaction.

**Meaning:** Primary mesh strip repair of umbilical hernias combines the simplicity of suture repair with the advantageous force distribution properties of mesh, and constitutes a safe, efficient, and effective method of repair with a low recurrence rate at long-term follow-up that is comparable to planar mesh repair.

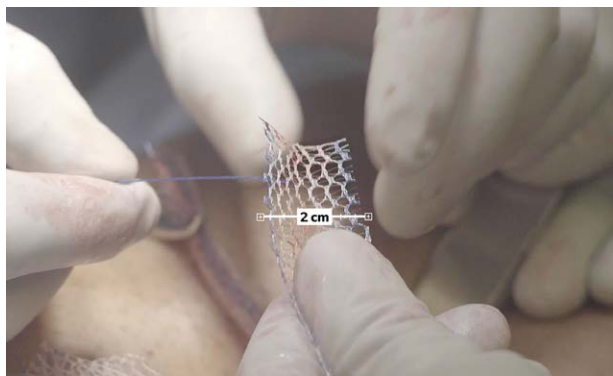
tissues are divided with scissors. The dissection is carried down to the abdominal wall and circumferentially around the umbilical stalk, which is then transected at its base. The hernia sac is identified and opened, and any preperitoneal fat or hernia contents are dissected free of the umbilical stalk and abdominal wall. The preperitoneal fat and hernia contents are then reduced into the abdominal cavity (Fig. 2). The edges of the fascial defect are defined, and the adjacent 1–2 cm of abdominal wall is cleared of soft tissue attachments. Similarly, the undersurface of the abdominal wall is cleared for a distance of 1–2 cm in the preperitoneal plane. Strips of mesh 18–20 mm in diameter are fashioned out of a 12×14 inch (30.5×35.6 cm) sheet of light-weight, macroporous, uncoated polypropylene mesh (PROLENE Soft Prolene Mesh; Ethicon, Somerville, N.J.). This width is achieved by cutting along the blue lines in the mesh sheet, and was designed to mimic the ultimate tensile strength of a number 1 polypropylene suture<sup>14</sup> (Fig. 3). The mesh strips of soft Prolene are attached at one end to a 0 polypropylene suture on a medium sized tapered needle, which



**Fig. 1.** Umbilical hernia defect incision design. A curved, infra-umbilical incision is marked at the junction between abdominal skin and umbilical skin, approximately from 3 o'clock to 9 o'clock.

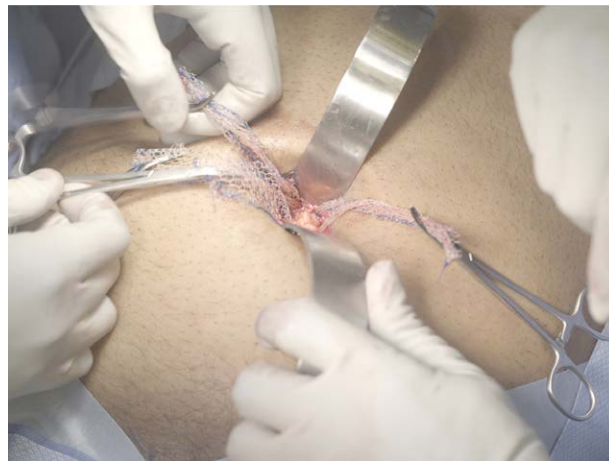


**Fig. 2.** Umbilical hernia defect. The hernia sac is identified via an infra-umbilical incision, opened, and hernia contents are dissected free of the abdominal wall and reduced.



**Fig. 3.** Preparation of mesh strips. Strips of mesh 18–20 mm in diameter are fashioned out of a 12×14 inch (30.5×35.6 cm) sheet of light-weight, macroporous, uncoated polypropylene mesh (PROLENE Soft Prolene Mesh; Ethicon, Somerville, N.J.). The mesh strip is seen being attached at one end to a 0 polypropylene suture for use as an introducing agent. Note that this width roughly corresponds to the distance between blue lines on the sheet of mesh.

is used as an introducing agent to minimize trauma to the abdominal wall. (See Video 1 [online], which shows mesh strips attached to introducing agent.) Tension is held onto the trailing edge of the strip while pulling the strip through the fascia so as to narrow the dimensions of the strip during passage. The defect is closed transversely with three to five mesh strips placed 6–8 mm apart from one another in simple interrupted fashion, taking fascial bites approximately 1 cm away from the fascial edge. (See Video 2 [online], which shows the placement of mesh strips.) To facilitate direct visualization and safe placement, all mesh strips are parachuted—that is, mesh strips are all placed and snapped before being subsequently tied (Fig. 4). Each mesh strip is tied with three throws (a single square knot and an additional throw for security),



**Fig. 4.** Placement of mesh strips. To facilitate direct visualization and safe placement, all mesh strips are parachuted—ie, mesh strips are all placed and snapped with hemostats before being subsequently tied.

and cut leaving tails 0.5-cm long. (See Video 3 [online], which shows the tying of mesh trips.) Placed and tied in this fashion, the surface area of mesh material facing the peritoneum or bowel is minimal. The umbilical stalk is then tacked back down to the abdominal wall with a dissolvable 2-0 polydioxanone suture. If the umbilicus was disrupted by the hernia, a neo-umbilicus may be created using two local “pumpkin-teeth” advancement flaps.<sup>15</sup> The skin is closed in layers with 4-0 monofilament dissolvable suture, and skin glue is applied. See Video 4 for full surgical technique. (See Video 4 [online], which shows umbilical hernia repair using mesh strips.)

#### Analysis of Outcomes

All of the senior author’s hernia patients are entered into a prospectively maintained database for baseline characteristics and operative details. A retrospective review of this prospectively maintained database was performed to include consecutive patients who underwent a mesh strip repair of an umbilical hernia defect between August 2016 and March 2021. Demographics, comorbidities, surgical history, and outcomes were collected for all patients. SSO was defined as any surgical site infection (SSI), seroma, hematoma, delayed wound healing, reoperation, or dehiscence. SSI was defined as a clinical diagnosis of wound infection based on the presence of wound erythema, drainage, and/or decision to initiate therapeutic postoperative antibiotics. Seroma was defined as a subcutaneous fluid collection in the postoperative period that was drained and did not require antibiotics for treatment. A suture abscess was defined as a delayed area of drainage associated with a surgical foreign body after incisional healing had taken place. Hernia recurrence was defined as a palpable fascial defect at the umbilicus associated with a bulge during a Valsalva or sit-up maneuver, as assessed by physical examination by the senior author. All readmissions and returns to the operating room for any reason within 30

**Table 1. Telephonic Questionnaire on PRO**

	Question	Response Options	Patient Response
1	How would you rate your current pain at your prior hernia site within the last 7 days?	Pain rated 0–10	0/10 (18/20) 10/10 (1/20) NR (1/20)
2	Do you feel the presence of the mesh if you are touching the surgery site?	Yes or No	Yes (2/20) No (18/20)
3	Do you feel the presence of the mesh if you are NOT touching the surgery site?	Yes or No	Yes (2/20) No (18/20)
4	Are you overall satisfied with the aesthetics of your repair?	Yes or No	Yes (15/20) No (2/20)
5	Have you had an improvement in your quality of life?	Yes or No	Yes (16/20) No (4/20)

Standardized questions specific to umbilical hernia repair with mesh strips were developed and asked via telephone (column 1). Standardized response options provided to the patient (column 2). Patient responses recorded at postoperative telephone follow-up (column 3). Twenty of 33 patients could be reached by phone and agreed to participate in the survey. NR: not recorded.

days were recorded. Length of follow-up was defined as the time from surgery to the last documented abdominal wall examination in the electronic medical record. This study was approved by the Northwestern University institutional review board.

#### Patient-reported Outcomes Questionnaire

Patients meeting inclusion and exclusion criteria described above were eligible to participate in a structured telephone questionnaire specifically designed to assess patient-reported outcomes (PROs) after mesh sutured umbilical hernia repair. These patients were contacted by telephone after institutional review board approval of the study. Patients reporting limitations in their level of activity or functional capacity due to medical comorbidities, or who reported being pregnant, were excluded from the questionnaire. Those patients who agreed to participate in the telephonic survey were asked a series of questions after they had undergone surgery (please refer to Table 1 for description of full survey). Telephonic surveys were conducted by two investigators with medical training. Responses were recorded in a standardized fashion. In cases where answers were unclear or contradictory, patients were re-contacted via telephone for clarification. Descriptive statistics were calculated with computer software (Microsoft Excel, Microsoft Corporation, 2022).

## RESULTS

#### Patient Cohort Description

Thirty-three consecutive patients underwent mesh strip repair of a primary umbilical hernia and met criteria for inclusion in the study. There were 20 men (61%) and 13 women (39%), ranging in age from 25 to 68 years (average age 43 years; median age 46 years). Average body mass index was 26 (range 16–37). Four patients (12%) had a history of diabetes, and three patients (9%) had a documented history of smoking. All patients had a fascial defect in the abdominal wall at the level of the umbilicus measuring 3 cm or less in diameter, as documented in the operative report or preoperative CT scan when available. All repairs were Centers for Disease Control Grade 1 clean cases.<sup>16</sup>

#### Outcomes

Follow-up ranged from 309 to 1982 days, with a median follow-up of 1136 days and an average follow-up of 1075 days (3 years). Operative time averaged 69 minutes (range 32–101 minutes), excluding combination procedures. There was one patient with a documented SSO, consisting of an SSI characterized by wound erythema successfully treated with oral antibiotics alone. There were no seromas, hematomas, delayed wound healing, suture abscess, reoperations, or dehiscence. There were no mesh strip exposures. Of the 33 patients included in this study, there was one documented case of umbilical hernia recurrence in a patient with recurrent chylous ascites in the setting of a failed TIPS (transjugular intrahepatic portosystemic shunt) procedure; this patient's revision surgery is pending medical optimization.

#### Patient-reported Outcomes

An estimated 20 of 33 (60%) of patients responded to the PRO telephonic survey and agreed to participate. Eighteen of 20 (90%) survey responders reported a pain score of 0 of 10 at the umbilical hernia operative site within the last 7 days. One patient-reported a pain score of 10 of 10. One patient did not respond to the question. Eighteen of 20 (90%) patients reported being unable to feel the presence of a knot at baseline, or when touching the surgical site. Fifteen of 20 (75%) patients responded they were satisfied with the aesthetics of the repair. Finally, 16 of 20 (80%) reported an improvement in quality-of-life after mesh strip umbilical hernia repair (Table 1).

## DISCUSSION

Simple suture repair of hernia defects is technically straightforward but can result in an unacceptably high rate of hernia recurrence. Indeed, the recurrence rate for simple suture repair of abdominal incisional hernias has been reported to be upward of 60%.<sup>17,18</sup> Even small umbilical hernias, arguably a less challenging clinical problem than incisional hernias, yield a disappointingly high rate of recurrence of 21% when repaired with a simple suture technique.<sup>8</sup> The use of mesh prosthetics in the repair of umbilical hernias has significantly decreased the risk of

recurrence, with several randomized clinical trials demonstrating a benefit of mesh repair over suture repair.<sup>19–21</sup> This has prompted the recent publication of guidelines recommending use of flat meshes for umbilical hernia repair.<sup>2</sup>

The improved durability of a mesh repair over a suture repair may be conceptualized by considering the physical construct from a biomechanical perspective. In a suture repair, tied loops of suture exert a tensile force to both approximate the edges of the umbilical hernia defect, and counteract the extensile forces from the elasticity of the fascia and surrounding soft tissues.<sup>22</sup> Additionally, the umbilical hernia repair is subjected to the forces of muscle contraction and sizable physiologic variations in intraabdominal pressure (eg, coughing).<sup>23</sup> The interplay of these static and dynamic forces at the STI, coupled with the biological strength of tissue healing, determine the fate of the repair. If the expansile forces overcome the tensile forces holding the tissues together, the result is either “cheesewiring,” as the suture pulls through the tissue, or suture rupture, leading to failure. As the number of sutures used for a repair increases, the forces at each STI decrease, distributing the forces and diminishing the likelihood of cheesewiring or suture breakage.<sup>7</sup> This has been elegantly demonstrated in abdominal wall surgery with the STITCH trial and is the rationale behind the “short stitch technique.”<sup>24</sup> Mesh exists on this continuum as it is essentially a linear (ie, one-dimensional) suture woven into a two-dimensional textile or three-dimensional matrix. Thus, mesh is capable of distributing forces across an even greater number of strands as well as a larger surface area, yielding a physical construct with significant biomechanical advantages.<sup>25</sup>

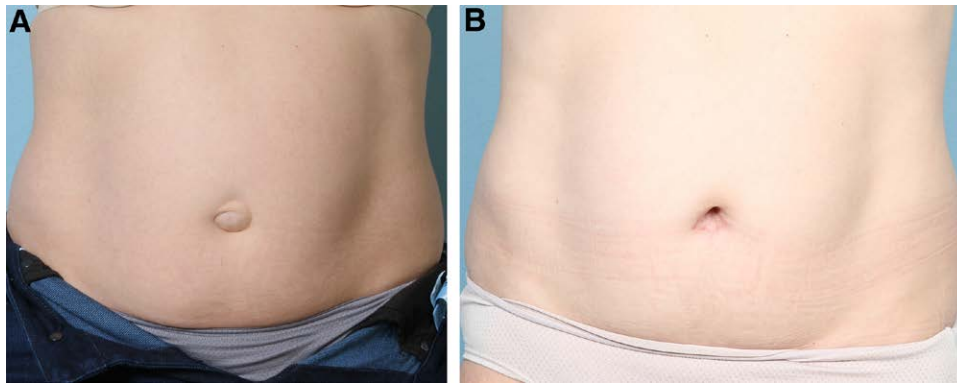
However, the use of planar meshes for the repair of small umbilical hernias is not without some notable technical disadvantages. There must be sufficient overlap between the mesh and the abdominal fascia to securely repair the defect. Overlap of less than 1 cm is associated with higher risk of recurrence,<sup>26</sup> and at least 3 cm of overlap is recommended.<sup>2</sup> This necessitates sufficient mobilization of soft tissue at the abdominal fascia to accommodate placement and adequate fixation of a flat mesh. For small umbilical hernias, the fascial defect may not be large enough to physically accommodate the insertion of a planar mesh in the intraperitoneal, preperitoneal, or retro-rectus plane. Widely mobilizing preperitoneal tissues to accommodate significant mesh overlap may be technically challenging to perform safely through a small orifice. Consequently, surgeons may be forced to enlarge the umbilical hernia defect to subsequently repair it with a planar mesh.<sup>11</sup> Soft tissues must be more widely elevated, leading to increased SSO. Overlay meshes obviate the need to increase the size of the fascial defect, but then the foreign body rests immediately under the skin increasing the chance for exposure, chronic drainage, and palpability.

The mesh strip technique for umbilical hernia repair has been described for larger repairs where there is a downside to the opening of additional tissue planes for the placement of a large mesh.<sup>27</sup> Our mesh strip technique decreases the likelihood of suture pull-through by modulating the STI.<sup>22</sup> A 2-cm strip of mesh provides 34 times the

surface area of a number 1 polypropylene suture while minimizing the total volume of implanted foreign material.<sup>14</sup> Conceptually, in a mesh strip repair, all the polypropylene filaments are located at the repair site. This is in contrast to a planar mesh repair, where most of the foreign material is located at some distance from the abdominal defect. The flatter, broader profile of a mesh strip passed through soft tissue and tensioned distributes the forces at the STI better than a small caliber suture.<sup>7</sup> Mechanically, this decreases the risk that the forces at the leading edge of the suture exceed the burst strength of tissue, protecting against the suture slicing through the tissue. Biologically, this translates into lower pressures experienced by the tissues within a loop of suture, shielding the tissue from pressure-induced necrosis.<sup>7</sup> As the tissues heal after mesh suture repair, the macroporosity of the implant permits tissue ingrowth and functions as a scaffold for scar formation. This redirects the foreign body response, generating scar tissue that reinforces the strength of the repair with time.<sup>14,25</sup> A mesh strip repair permits synergy between the mechanical mesh construct and the biological healing response as the size and shape of the implant facilitates both issues.

With a mean follow-up time of nearly 3 years, our recurrence rate of 3% after mesh strip umbilical hernia repair is comparable to recurrence rates for umbilical hernia repair with planar mesh (3.6%) and lower than simple suture repair (11.4%) as reported in a recent randomized clinical trial with 2-year follow-up.<sup>21</sup> The one patient with a recurrence developed this complication in the setting of recurrent ascites, a known independent risk factor for umbilical hernia recurrence.<sup>28</sup> There was one patient with an SSI in our study population, successfully treated with oral antibiotics not requiring drainage. Although all elective mesh strip umbilical hernia repairs presented here were classified as Centers For Disease Control 1 clean cases,<sup>16</sup> a low rate of SSI is consistent with our experience performing mesh sutured repair of large ventral hernias even in contaminated fields.<sup>14,27</sup> Our PRO questionnaire revealed that 10% of patients reported feeling the presence of mesh. Two patients reported pain at the surgical site within the last 7 days, and the remaining 90% indicated they had no pain, consistent with a recent meta-analysis of umbilical hernia repair outcomes.<sup>5</sup> Chronic pain can be a complication of umbilical hernia repair irrespective of the use of mesh.<sup>29</sup> Still, some surgeons are reluctant to use mesh for repairing small hernias for fear of complications such as chronic pain, as seen in inguinal hernia repair.<sup>8</sup> In contrast to planar mesh repairs, mesh strip repair minimizes the total amount of implanted mesh by confining it to the repair site. Additionally, because our technique consists of repurposing a planar piece of mesh by cutting it into mesh strips to use as sutures, the cost of a mesh strip umbilical hernia repair should be the same as a planar mesh repair. Average operative time for our mesh strip repair (69 min) was comparable to operative times published for planar mesh repair (44 min).<sup>21</sup> Overall, this technique for umbilical hernia repair was associated with an improvement in quality of life and a high rate of patient satisfaction.

There are limitations to our study, including its single-arm, retrospective design, small sample size, and



**Fig. 5.** Patient photographs. Representative preoperative photograph (A), and postoperative photograph (B).

single-institution experience. The senior author again discloses his conflict of bringing to market a mesh suture that may facilitate the technical performance of this procedure. Additionally, although our PRO telephone survey was specifically designed for assessing umbilical hernia repair with mesh strips, it was not a validated PRO instrument and did have a limited responder rate of 60%. Nevertheless, we are encouraged by our low recurrence rate of 3% with a mean postoperative follow-up of nearly 3 years, comparable to outcomes seen with planar mesh repairs and better than simple suture repair.<sup>8,30</sup> Long-term independent comparative studies evaluating safety, effectiveness, and cost are needed to validate our approach to umbilical hernia repair. A randomized controlled trial comparing mesh suture to standard suture is underway.

## CONCLUSIONS

We introduce a novel mesh strip repair of umbilical hernias that blends the simplicity of suture repair with the advantageous force distribution properties of mesh. This technique offers an attractive alternative to simple suture repair or planar mesh repair of small (<3 cm) umbilical hernias without significant associated rectus diastasis. PROs are favorable (Fig. 5.)

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## DISCLOSURES

*Dr. Dumanian is the founder and medical officer of Mesh Suture Inc. and has intellectual property concerning a mesh suture. He may stand to benefit from the results of this study. All the other authors have no financial interest in relation to the content of this article.*

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