OPEN

PRS GLOBAL OPEN

ORIGINAL ARTICLE
Reconstructive

T-line Hernia Mesh Repairs of Large Umbilical Hernias: Technique and Short-term Outcomes

Hani I. Naga, MD
Emmanuel Emovon, BS
Joshua K. Kim, BS
Jorge Andres Hernandez, MD, MBA
Jin S. Yoo, MD

Background: The T-line hernia mesh is a synthetic, polypropylene mesh specifically designed to prevent anchor point failure by evenly distributing tension through mesh suture extensions. This case series illustrates the first clinical application of the T-line mesh for umbilical hernia repair (UHR).

Methods: This study is a retrospective, consecutive cases series of all adult patients presenting to a single surgeon with symptomatic umbilical hernia requiring surgical repair using the T-line hernia mesh. Patient demographics, surgical details, and 30-day postoperative complications were collected. Descriptive statistics were computed in Microsoft Excel (Redmond, Va.).

Results: Three patients presented for UHR. All three patients were obese with mean body mass index of 37.5 ± 6.6. Two patients were former smokers, and two had presented after hernia recurrence. The average defect size was 80.1 cm^2 ± 94.0 cm^2. Two patients had UHR with onlay mesh placement, whereas one had a transversus abdominus release followed by retrorectus mesh placement. The average mesh size was 192.3 cm^2 ± 82.5 cm^2. All three cases were classified as clean. There were no intraoperative complications. No patients experienced 30-day postoperative complications or recurrence.

Conclusions: We present a case series of three patients presenting with large, symptomatic umbilical hernias who underwent UHR with T-line hernia mesh reinforcement without short term complications or hernia recurrence at last follow-up.
(Plast Reconstr Surg Glob Open 2024; 12:e5668; doi: 10.1097/GOX.0000000000005668; Published online 20 March 2024.)

INTRODUCTION

Umbilical hernias are midline abdominal wall defects that lie within 3 cm of the umbilicus.[1] An estimated 2% of the United States population experiences umbilical hernias, with higher incidences in obese and cirrhotic patients.[2] Umbilical hernia repairs are associated with recurrence rates of 2.7% and 27%, in mesh repair and nonmesh repair respectively.[3] To minimize recurrence, surgical mesh reinforcement has become increasingly used, but inherent differences in composition of surgical meshes adds complexity to surgical decision-making. In addition, patient-related factors such as obesity and hernia recurrence further complicate surgical repair, necessitating nuanced surgical decision-making to ensure durable repairs.

The T-line hernia mesh by Deep Blue Medical Advances Inc. is a novel surgical mesh that has been used primarily for ventral hernia repair and abdominal wall reconstruction.[4–6] T-line mesh is a synthetic, polypropylene mesh that incorporates mesh suture extensions with a 15 times larger surface area for fixation compared with monofilament sutures.[7,8] This results in mesh anchoring that is 275% stronger than standard monofilament suture fixation as evidenced by prior biophysical studies, and strength may actually increase over time as these suture extensions incorporate into the surrounding tissue.[7,8] In addition, mesh suture fixation disperses tension on abdominal fascia, thereby reducing the cheese-wiring effect of monofilament suture fixation which contributes to mesh failure. Overall, these aforementioned features are thought to contribute to a more durable repair. Importantly, as of December 7, 2022, the T-line mesh has

From the Department of Surgery, Duke University Hospital, Durham, N.C.

Received for publication October 11, 2023; accepted January 22, 2024.

DOI: 10.1097/GOX.0000000000005668

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

Related Digital Media are available in the full-text version of the article on www.PRSGlobalOpen.com.

received FDA approval and is available in a range of sizes, which can be trimmed to various shapes, enhancing its versatility and clinical applicability.

Although other studies have demonstrated the utility of T-line mesh in various clinical applications, no studies to date have characterized its use in umbilical hernia repair (UHR). The aim of this study was to present preliminary clinical outcomes associated with the use of T-line mesh for UHR.

METHODS

Study Design

Institutional review board exemption was obtained for this study. Patients who underwent UHR with T-line mesh by a single surgeon between July 2021 and October 2022 were included. Patient demographics, comorbidities, and history of prior abdominal surgery were obtained. Operative notes were examined for hernia defect size, mesh size, and adjuncts, such as component separation. UHR was classified based on the location of the hernia and appearance on corresponding diagnostic imaging. Of note, all cases in this series had either port hernias from prior minimally invasive abdominal surgery or recurrent umbilical hernias after failed open repair. Ninety-day complications (including surgical site reinfection, wound dehiscence, readmission, and reoperation) were noted. Systemic complications such as pulmonary embolus, myocardial infarction, acute renal failure requiring dialysis, or deep venous thrombosis was recorded. Patients were also evaluated for pain scores at their postoperative follow-up appointment. Descriptive statistics were completed using Microsoft Excel (Redmond, Wa.).

Surgical Technique

After hernia reduction, lysis of adhesions, and excision of hernia sac, the skin and fascial defect is inspected. Our preferred plane of mesh placement is the retrorectus plane, although if a large amount of lipocutaneous advancement is required for skin closure, the onlay plane is chosen to decrease dissection burden. Using kocher clamps, the abdominal wall is assessed for feasibility of tension free primary fascial closure. If a component separation is required, it is performed in the associated plane for planned mesh placement. Generally, we aim for at least 5cm of mesh/fascial overlap, depending on the defect characteristics. The T-line mesh (Fig. 1) is then brought into the operating field and contoured to fit the hernia defect with adequate fascial edge overlap. The mesh tension is adjusted along one side of the defect and the mesh suture is passed through the fascia at the desired fixation point. To ensure a secure hold, an additional pass is made through both the mesh and fascia. A horizontal locking suture is then placed, encompassing both the mesh and fascia, and this process is repeated for all fixation points along the repair. The tension of the mesh is set by securing the contralateral side and offloading pressure from the midline repair. To fix the mesh at the superior and inferior aspects, mesh suture extensions are cut from the mesh and utilized with the same locking technique. The mesh should be taut and flush against the abdominal wall. Following placement of a surgical drain for postoperative monitoring, the skin wounds were closed in multiple layers. The supplemental video depicts T-line mesh fixation in an onlay UHR. [See **Video (online)**, which shows a T-line hernia mesh umbilical hernia repair technique.]

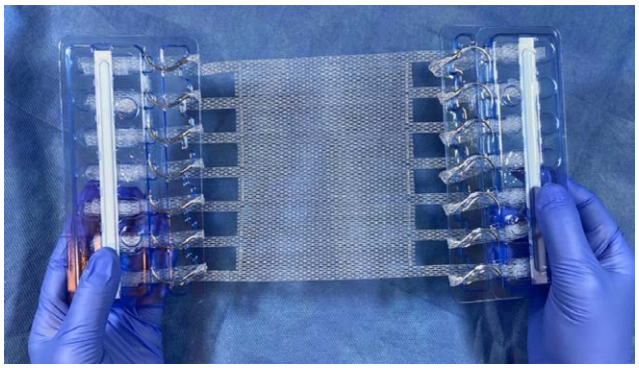

Fig. 1. T-line hernia mesh with suture extensions.

Takeaways

Question: How is the T-line hernia mesh applied to large umbilical hernias? What are short-term recurrence and complication rates after index operations?

Findings: A video demonstration of an umbilical hernia repair (UHR) with primary fascial closure and onlay T-line hernia mesh application is provided. A three-patient case series demonstrated no short term complications and no recurrences.

Meaning: This series demonstrates the successful application of a novel hernia mesh to large, complex UHRs. More robust studies and clinical trials are required to assess long-term efficacy in UHRs.

CASE PRESENTATIONS

Patient demographics, operative details, and short-term outcomes can be found in Table 1.

Case 1

Patient 1 was a 64-year-old man who presented with a reducible umbilical hernia. Of note, he had no recollection of prior abdominal surgery, and was a former smoker with a body mass index (BMI) of 31.97 kg/m². He was taken to the operating theater for an elective open UHR. A vertical midline incision was designed to expose the hernia, and he was found to have a 10 cm by 20 cm umbilical hernia defect with incarcerated but viable omentum. After mobilization and lysis of adhesions, the hernia was reduced. The patient was noted to have prior suture material in his fascial defect, which was dissected out and completely removed. Due to the size of the hernia

Table 1. Patient Demographics and Postoperative Outcomes After UHR

	N (%)
Patient Demographics	
Total patients	3
Age (y, median, IQR)	60.9±5.1
Sex	
Male	1 (33.3%)
Female	2 (66.7%)
BMI (kg/m², median, IQR)	37.5±6.6
Hypertension	1 (33.3%)
Immunosuppressed	0 (0.0%)
ASA class	
I	0 (0.0%)
II	2 (66.7%)
III	1 (33.3%)
Recurrent hernia	2 (66.7%)
Diabetes mellitus	0 (0.0%)
Smoking status	
Never	1 (33.3%)
Former	2 (66.7%)
Current	0 (0.0%)
EHS class	
M1	0 (0.0%)
M2	0 (0.0%)
M3	3 (100.0%)
EHS width	
W1	0 (0.0%)
W2	2 (66.7%)
W3	1 (33.3%)
Surgical Characteristics	
Operative time (min, median, IQR)	203.0±41.0
Primary fascial closure	3 (100%)
Defect size (cm², median, IQR)	80.1±94.0
Defect length (cm, median, IQR)	6.1±3.5
Defect width (cm, median, IQR)	9.8±8.0
Hernia repair plane	
Onlay	2 (66.7%)
Retrorectus	1 (33.3%)
Wound classification: clean (I)	3 (100.0%)
Recurrence	0 (0.0%)
Intraoperative complication	0 (0.0%)
Mesh size (cm², median, IQR)	192.3±82.5
Mesh: defect ratio (median, IQR)	5.9±4.9
Additional fixation	
None	3 (100.0%)
30 day emergency department	0 (0.0%)
30 day complication	0 (0.0%)
Follow-up (days, median, IQR)	23.4±16.0

ASA, American Society of Anesthesiologists; BMI, body mass index; EHS, European Hernia Society; IQR, interquartile range.

defect and the challenges in achieving tension free midline fascial edge approximation, the decision was made to perform a unilateral transversus abdominus release. This allowed for successful primary closure of the fascia and adequate mesh placement. The posterior rectus sheath was then closed using 2-0 absorbable braided suture in a continuous fashion. A 10 cm by 30 cm sheet of T-line hernia mesh was affixed from xiphoid to pubis in the retrorectus space. Mesh suture extensions were passed from the retrorectus space through the abdominal wall. The anterior rectus fascia was then closed with running 2-0 running monofilament suture. The patient was discharged on postoperative day 1 with standard pain management regimen, no antibiotics, and activity restrictions of no lifting greater than 15 pounds for 6 weeks. At the first postoperative visit, the surgical drain was removed. The rest of the patient's postoperative course was unremarkable, with last known follow-up 90 days after surgery. At the final postoperative visit, the patient reported zero pain, which was consistent with his initial consultation. He was noted to have no complications or recurrence at this point and had begun physical therapy. The patient was subsequently lost to follow-up.

Case 2

Patient 2 was a 64-year-old woman with a medical history significant for morbid obesity and tubal ligation who presented with a symptomatic umbilical hernia. The patient was a nonsmoker with a BMI of 45.06 kg per m² and was initially scheduled for an elective laparoscopic hernia repair. Upon exploration, the patient had incarcerated omentum and transverse colon through a relatively small neck with a 6 cm diameter. Given the difficulty with laparoscopic reduction, the surgery was converted to an open procedure. The hernia sac, along with the effaced overlying skin, was excised and passed off for pathologic analysis. To facilitate skin advancement, lipocutaneous undermining was performed to provide a platform for onlay mesh placement. The hernia defect was then closed with multiple 0 absorbable monofilament sutures in a figure-of-eight manner. A 13.5 by 10.5 cm sheet of T-line hernia mesh was placed as an onlay mesh and affixed to the anterior abdominal wall. The patient was discharged on the same day with standard pain management regiment, no antibiotics and activity restrictions of no lifting greater than 15 pounds for 6 weeks. The surgical drain was subsequently removed at the first postoperative visit. Her postoperative course was unremarkable. Her last follow-up was 30 days after surgery without any noted hernia recurrence or surgical site infection. At the final postoperative visit, the patient reported 0 of 10 pain, which was consistent with her initial consultation. The patient was subsequently lost to follow-up.

Case 3

Patient 3 was a 53-year-old woman with a medical history of obesity and history of UHR. She presented with diffuse abdominal pain due to a recurrent umbilical hernia. The patient was a former smoker with a BMI of 35.38 kg/m². She was taken to the operating theater for an elective open UHR. In the operating room, the patient was noted to have a prior permanent synthetic mesh that had lost integrity and resulted in fascial dehiscence at the site of prior primary fascial closure. The prior mesh was carefully explanted away from the hernia sac, the fascial edges, and the underlying omentum. The hernia was reduced, and the resultant defect was then closed without tension with interrupted 2-0 polypropylene sutures.

A 13.5 cm by 10.5 cm sheet of T-line hernia mesh was affixed to the anterior abdominal wall. The patient was discharged on the same day with standard pain management regimen, no antibiotics, and activity restrictions of no lifting greater than 15 pounds for 6 weeks. At the first postoperative visit, the surgical drain was removed. Her postoperative course was unremarkable. Her last follow-up visit was approximately 1 year after surgery without any noted hernia recurrence or surgical site infection. At the final postoperative visit, the patient reported a pain score of two, which was consistent with her initial consultation.

DISCUSSION

This case series is the first demonstrated clinical application of the T-line mesh in UHR. All three patients had risk factors for complications, including obesity (BMI > 30), recurrent UHR, and concurrent component separation. All patients had sizeable fascial defects requiring open repairs, and due to the complexity of the hernia defects, T-line mesh was used. No patients in this series had 30-day complications, and in one patient who presented for follow-up at 1 year, there was no observed hernia recurrence.

Mesh repairs of UHR have become standard of care, as prior studies have demonstrated unacceptable recurrence rates in suture only repairs.[9,10] However, optimal mesh selection continues to be a challenge as each device has different advantages and disadvantages.[11] In theory, the ideal prosthetic mesh should be durable, pliable, noncarcinogenic, inert, nonimmunogenic, and nonbiodegradable throughout the wound healing process.[12] The T-line hernia mesh is an innovative device that allows for affixation of permanent mesh with mesh suture extensions that prevent anchor point failure, which reduces the risk of hernia recurrence.

The patients in this series presented with challenging repairs complicated by multiple comorbid conditions, including prediabetes, hypertension, obesity, smoking histories, and prior hernia repairs. These conditions increase the risk of postoperative complications and hernia recurrence.[13,14] In particular, obesity is a known risk factor for hernia recurrence due to increased mechanical stress on the abdominal wall.[15] In addition, these medical comorbidities are all associated with increased rates of surgical site infection. Of note, no patients in this series presented with surgical site infections despite the use of a synthetic permanent mesh.

Obese patients are prone to complications such as surgical site infection, wound dehiscence, and hernia recurrence, and as such, often require component separations or large underlay mesh repairs.[16,17] In addition, the obese population has been shown to have higher umbilical and ventral hernia recurrence rates in the literature, regardless of mesh type and plane of implantation.[18,19] As such, the T-line mesh may prove particularly beneficial in this population as the more integrated mesh fixation may counteract the heightened risk of mesh migration and failure in this population.

This study has significant limitations due to its small sample size and the short overall follow-up duration. The included cases reflect a single surgeon's utilization of this hernia mesh, and as such, criteria for plane of mesh implantation are not standardized but rather reflect the senior author's practice. This study was not meant to test a hypothesis, but rather demonstrates a novel clinical application of an innovative surgical device. Larger clinical studies are necessary to provide additional insights for safety and performance of this mesh.

CONCLUSIONS

This case series demonstrates application of the T-line hernia mesh to UHR in obese patients with recurrent hernias and large fascial defects. In this series, there were no short-term complications.

Jin S. Yoo, MD
Division of Metabolic and Weight Loss Surgery
Duke Department of Surgery
407 Crutchfield St
Durham, NC 27704-2726

DISCLOSURE

Dr. Jin Yoo is a paid medical consultant for Deep Blue Medical Advances. All the other authors have no financial interest to declare in relation to the content of this article.

REFERENCES

1. Muysoms FE, Miserez M, Berrevoet F, et al. Classification of primary and incisional abdominal wall hernias. *Hernia.* 2009;13:407–414.
2. Dabbas N, Adams K, Pearson K, et al. Frequency of abdominal wall hernias: is classical teaching out of date? *JRSM Short Rep.* 2011;2:5.
3. Appleby PW, Martin TA, Hope WW. Umbilical hernia repair: overview of approaches and review of literature. *Surg Clin North Am.* 2018;98:561–576.
4. Lima DL, Mohamedaly S, Hollins A, et al. A novel polypropylene mesh (T-line) for abdominal wall repair: early experience at three centers in the United States. *Surg Technol Int.* 2023;42:sti42/1649.
5. Perrault D, Arquette C, Sharma A, et al. T-line mesh as a safe and effective option for abdominal wall reinforcement with autologous breast reconstruction. *J Plast Reconstr Aesthet Surg.* 2023;84:273–275.
6. Hollins AW, Levinson H. Report of novel application of T-line hernia mesh in ventral hernia repair. *Int J Surg Case Rep.* 2022;92:106834.
7. Ibrahim MM, Green JL, Everitt J, et al. Soft tissue anchoring performance, biomechanical properties, and tissue reaction of a new hernia mesh engineered to address hernia occurrence and recurrence. *J Med Dev.* 2019;13:045002.
8. Ibrahim MM, Poveromo LP, Glisson RR, et al. Modifying hernia mesh design to improve device mechanical performance and promote tension-free repair. *J Biomech.* 2018;71:43–51.
9. Aiolfi A, Cavalli M, Micheletto G, et al. Open mesh vs. suture umbilical hernia repair: systematic review and updated trial sequential meta-analysis of randomized controlled trials. *Hernia.* 2020;24:707–715.
10. Kaufmann R, Halm JA, Eker HH, et al. Mesh versus suture repair of umbilical hernia in adults: a randomised, double-blind, controlled, multicentre trial. *Lancet (London, England).* 2018;391:860–869.

11. Lak KL, Goldblatt MI. Mesh selection in abdominal wall reconstruction. *Plast Reconstr Surg*. 2018;142:99S–106S.
12. Rastegarpour A, Cheung M, Vardhan M, et al. Surgical mesh for ventral incisional hernia repairs: understanding mesh design. *Plastic Surgery (Oakville, Ont.)* 2016;24:41–50.
13. Krpata DM, Blatnik JA, Novitsky YW, et al. Evaluation of high-risk, comorbid patients undergoing open ventral hernia repair with synthetic mesh. *Surgery*. 2013;153:120–125.
14. Lindmark M, Strigård K, Löwenmark T, et al. Risk factors for surgical complications in ventral hernia repair. *World J Surg*. 2018;42:3528–3536.
15. Dietz UA, Kudsi OY, Gokcal F, et al. Excess body weight and abdominal hernia. *Visc Med*. 2021;37:246–253.
16. Giordano SA, Garvey PB, Baumann DP, et al. The impact of body mass index on abdominal wall reconstruction outcomes: a comparative study. *Plast Reconstr Surg*. 2017;139:1234–1244.
17. Lau B, Kim H, Haigh PI, et al. Obesity increases the odds of acquiring and incarcerating noninguinal abdominal wall hernias. *Am Surg*. 2012;78:1118–1121.
18. Shankar DA, Itani KMF, O'Brien WJ, et al. Factors associated with long-term outcomes of umbilical hernia repair. *JAMA Surg*. 2017;152:461–466.
19. Patrick Hamid A, Anne A, Eric L, et al. Impact of obesity on postoperative complications after laparoscopic and open incisional hernia repair—a prospective cohort study. *Int J Surg*. 2017;48:220–224.