Phasix™ Mesh

Fully resorbable scaffold for hernia repair

Designed to enable functional tissue remodeling for a strong repair.[1]

BD

Materials used in challenging ventral hernia repair

1960s

Permanent synthetic meshes

Used since the 1960s to reduce the rate of recurrence[2]

Advantages:

- Incorporate rapidly into host tissue
- Reduce recurrence versus primary closure

Disadvantages:

- In some instances, complications may occur, requiring removal

1990s

Biologic grafts

Introduced in the 1990s as an alternative to synthetic mesh for high-risk patients

Advantages:

- Fully absorbable over time — no long-term permanent material
- Reduce the need for removal if a complication occurs[3]

Disadvantages:

- Microporous structure may increase vulnerability of bacterial colonization[4]
- Bacterial colonization may lead to accelerated enzymatic degradation[5]
- Significantly more expensive than other materials used in hernia repair[6]

Today

Phasix™ Mesh

Surgeons need a material that has the benefits of both synthetics and biologics—without the limitations of long-term permanence and premature resorption in the presence of bacteria.[1,5,7]

The next phase in hernia repair

Phasix™ Mesh provides an open monofilament mesh for rapid tissue incorporation that has been designed to allow for the repair strength of a synthetic mesh, along with the remodeling characteristics of a biologic graft.[1]

Repairs[1]

The open monofilament mesh scaffold provides early integration and repair strength.[1]

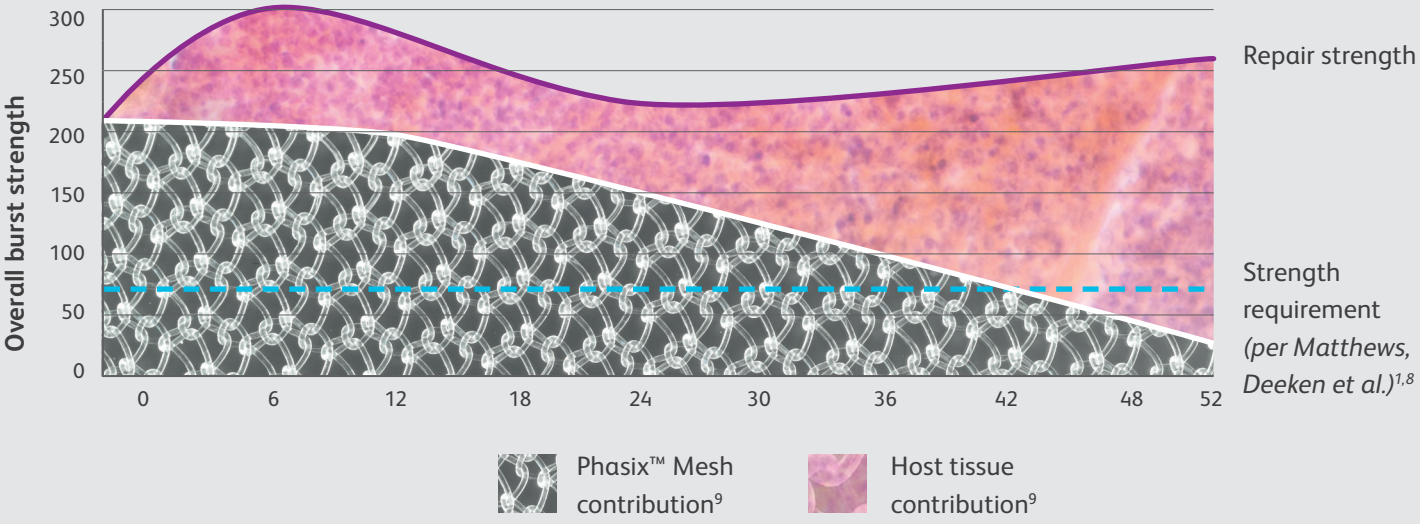
Remodels[1]

Preclinical testing confirms vascular integration and incorporation, with abundant mature collagen at 52 weeks. Gradually transfers load to native tissue over time.[1]

Restores[1]

As Phasix™ Mesh is remodeled, it is replaced with functional tissue, ultimately resulting in a strong repair at one year.[1]

Repair strength over time in a 52 week preclinical model[1]



Gradual transfer of strength from mesh to functional tissue.

What is Phasix™ Mesh?

Phasix™ Mesh is a knitted monofilament mesh scaffold using Poly-4-hydroxybutyrate (P4HB), a biologically derived material.

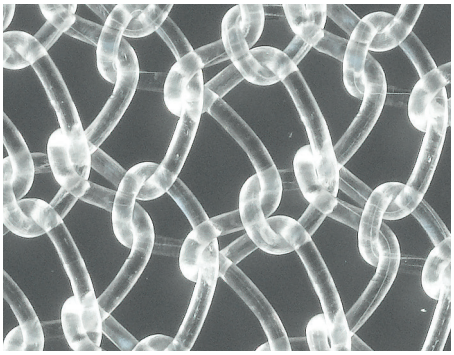
- Monomer form (4HB) is a naturally occurring human metabolite found in the brain, heart, liver, kidney, and muscle.
- Predictably resorbs through hydrolysis, as P4HB metabolizes into biocompatible byproducts *(CO_2 and H_2O).*

Monofilament mesh designs have been deemed more biocompatible[10,11] and less susceptible to bacterial adherence and colonization.[12,13,14]

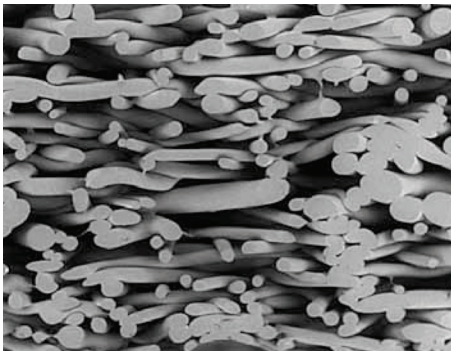
Material structure[1]

Material structure can impact host response.[13] Consider these features of monofilament versus multifilament structures.

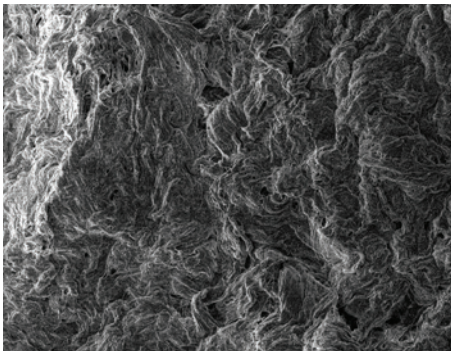
- Monofilament mesh design allows for a prompt fibroblastic response through the open interstices of the mesh.
- Material designs with complex architecture can have greater surface area and niches that bacteria can use as a haven from tissue ingrowth, neovascularization, antibiotic treatment, and host inflammatory response.[15]
- It has been reported that the surface area of multifilament material is 157% higher than monofilament materials.[15]



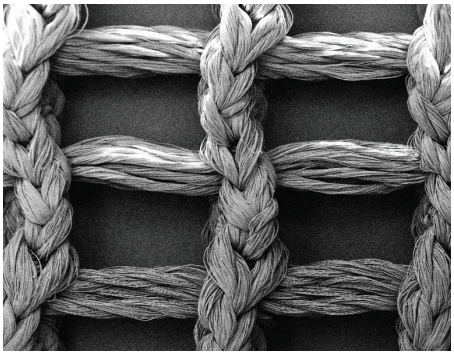
Phasix™ Mesh
Knitted monofilament, P4HB
SEM Photo, 20X



Bio-A® Tissue Reinforcement
Fibrous sheet material, unwoven structure, TMC/PGA
SEM Photo, 50X



Strattice™ Firm
Collagen sheet material, non-crosslinked porcine dermis
SEM Photo, 1,000X



SERI® Scaffold
Multifilament scaffold, derived from silk
SEM Photo, 17X

Preclinical studies

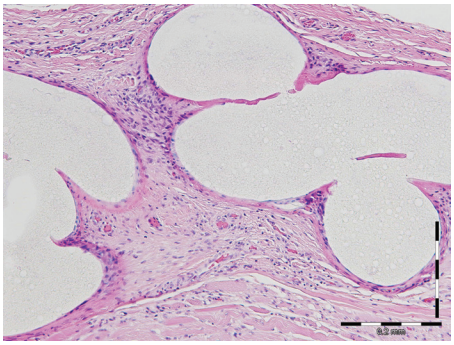
Numerous studies have determined that monofilament mesh designs provide a scaffold for rapid tissue incorporation and less surface area for bacterial adherence.[13,14,16] In order to characterize the morphological properties of Phasix™ Mesh, a number of preclinical studies were conducted.

Tissue incorporation[1]

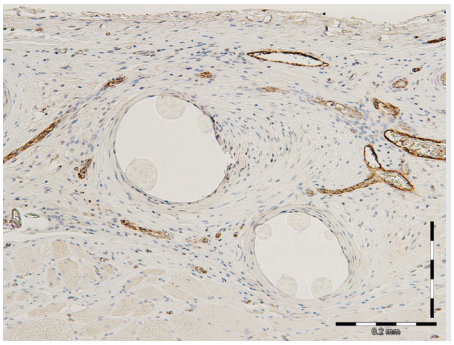
Study objective
Evaluate material strength and histopathology of Phasix™ Mesh.

Study design
A 3-centimeter round defect was created in the ventral abdominal wall of 25 Yucatan mini-pigs *(average weight 38 kg).* Phasix™ Mesh was fixated directly over the defect with SorbaFix™ resorbable tacks. Ball burst testing and histopathology were conducted at 6, 12, 26, and 52 weeks.

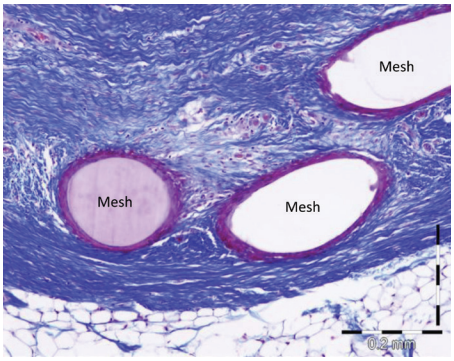
Results
Early tissue ingrowth, vascular integration, and incorporation of Phasix™ Mesh into the ventral abdominal wall, plus abundant mature collagen formed around the remaining fibers at 52 weeks.



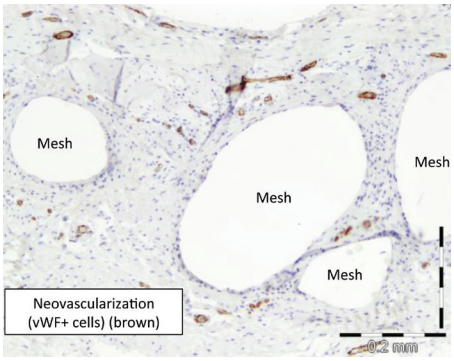
Phasix™ Mesh, 6 weeks, H&E, 10X
Pink: Collagen
Purple: Cells



Phasix™ Mesh, 6 weeks, vWF, 10X
Brown: Blood vessels



Phasix™ Mesh, 52 weeks, MT, 10X
Blue: Collagen
Purple: Macrophages surrounding monofilaments; mild host inflammatory response



Phasix™ Mesh, 52 weeks, vWF, 10X
Brown: Blood vessels

Strength over time

Phasix™ Mesh retains a greater amount of strength for a longer period of time versus other fully absorbable synthetic materials. In addition, it retains higher strength throughout the first several weeks, which is critical during the initial healing phase.[1,17]

Vicryl® Mesh[18]

- Consists of a copolymer of lactide and glycolide, both of which degrade by hydrolysis with acidic byproducts
- Up to 77% of the strength of this polymer is lost by two weeks as demonstrated in preclinical studies and the mesh is essentially completely resorbed by three months post-surgery

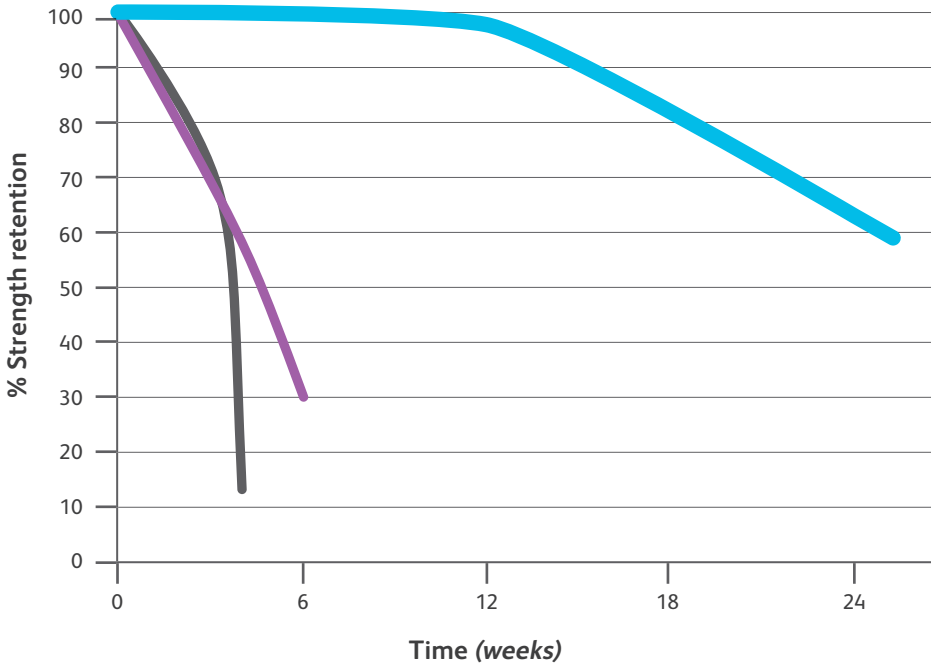
Bio-A® Tissue Reinforcement[18,19]

- Consists of both glycolide and trimethylene carbonate
- These materials break down into an acid, which in a preclinical model affected the surrounding micro-environment by increasing both inflammation and fibrosis
- 50% of Bio-A® is resorbed by five weeks post-implant and 100% of the Bio-A® is resorbed by seven months

Phasix™ Mesh[18]

- Consists of P4HB, a natural human metabolite
- Resorbs via hydrolysis and breaks down into CO_2 and H_20
- 52% strength reduction at 7.5 months

Relative material strength retention[1]



Phasix™ Mesh *(P4HB)*
Data on file at BD N=6

Vicryl® Suture
Obtained from Chu, et al 1982[20]

GTMC Suture
Obtained from Katz, et al 1985[19]

Published clinical performance

P4HB monofilament products have been commercially available since 2007, first as a suture and later in 2010 in a mesh configuration. Clinical and preclinical data on P4HB have been included in 58 published studies, including the following.

Preclinical data

Martin DP, Williams SF. Medical Applications of Poly-4-Hydroxybutyrate: a Strong Flexible Absorbable Biomaterial. *Biochemical Engineering Journal.* 2003;(16):97–105.

Summary

Poly-4-Hydroxybutyrate *(P4HB)* is strong yet flexible, and degrades in vivo at least in part by a surface erosion process. In vivo, the mechanical strength of P4HB gradually declines and it demonstrates good biocompatibility due to a slow release of well tolerated less acidic degradation products *(versus PGA).*

Preclinical data

Odermatt EK, Funk L, Bargon R, Martin DP, Rizk S, Williams SF. MonoMax® Suture: A New Long-Term Absorbable Monofilament Suture Made from Poly-4-Hydroxybutyrate. *International Journal of Polymer Science.* 2012;1–11.

Summary

Biocompatibility was evaluated for cytotoxicity, irritation, sensitization, acute systemic toxicity, pyrogenicity, genotoxicity, subchronic system toxicity and chronic toxicity; and tissue reaction was assessed by intramuscular implantation. All tests indicated that the MonoMax® suture presents an excellent biocompatibility and physiologically is well integrated in the tissues. Absorption of a size 3-0 suture was found to be substantially complete at about 64 weeks. It could be especially useful as a suture material for slowly healing tissues.

Clinical data

Albertsmeier M et al. "Evaluation of the safety and efficacy of MonoMax® suture material for abdominal wall closure after primary midline laparotomy — a controlled prospective multicenter trial: ISSAAC. *Langenbecks Archives of Surgery.* 2012;(397):363–371.

Conclusion

The ultra-long-term resorbable, elastic monofilament suture material MonoMax® is safe and efficient for abdominal wall closure.

Case reports

Two year follow up

Repair of Umbilical Hernias with a New Absorbable Synthetic Mesh *(Case report).*[21]

LeBlanc, Karl A MD

Clinical experience with Phasix™ Mesh: umbilical hernia repair in two patients with a Phasix™ Mesh onlay two-year follow up. No postoperative complications or evidence of recurrence.

Complex patient

Ventral Hernia Repair with Phasix™ Mesh: A Fully Resorbable Material.

Parra-Davila, Eduardo MD, FACS, FASCRS

Clinical experience with Phasix™ Mesh: recurrent hernia repair in a diabetic patient with complex medical history, including multiple surgeries, wound infections, and comorbidities. After open ventral herniorrhaphy and onlay placement of Phasix™ Mesh, no postoperative complications and no evidence of short-term recurrence through 25-day postoperative follow up.

Material indication

Phasix™ Mesh is indicated to reinforce soft tissue where weakness exists in patients undergoing plastic and reconstructive surgery, or for use in procedures involving soft tissue repair, such as the repair of hernia or other fascial defects that require the addition of a reinforcing or bridging material to obtain the desired surgical result. [22]

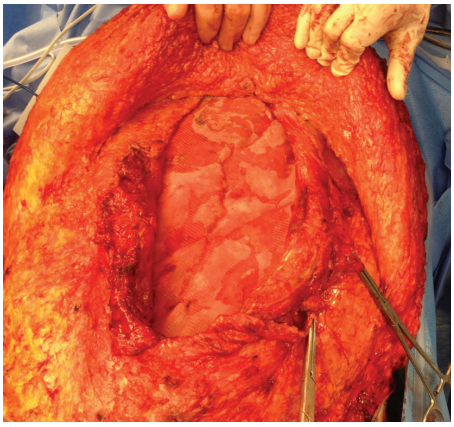
Material selection

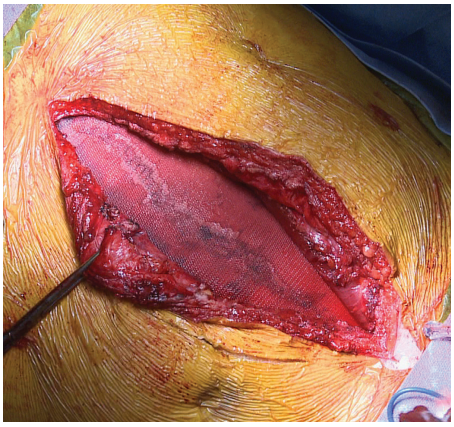
Phasix™ Mesh degrades through a process of hydrolysis and a hydrolytic enzymatic digestive process. It has been developed to enforce areas where weakness exists while minimizing the variability of resorption rate *(loss of mass)* and strength to provide support throughout the expected period of healing.[1] Phasix™ Mesh must not be put in direct contact with bowel or viscera. Further, If an infection develops, treat the infection aggressively. Consideration should be given regarding the need to remove the mesh. An unresolved infection may require removal of the device.[22]

Placement techniques

Phasix™ Mesh can be used to reinforce soft tissue repair. Examples below demonstrate onlay and retrorectus repairs.

Retrorectus placement



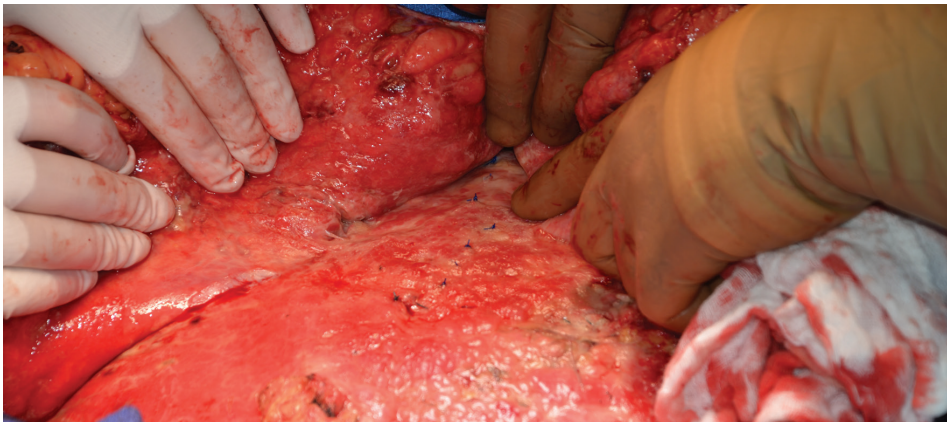


Phasix™ Mesh placed in the retrorectus position.

Photos courtesy of
Eduardo Parra-Davila, MD
Florida Hospital Celebration Health *(left).*

Yuri Novitsky, MD
University Hospitals Case Medical Center *(right).*

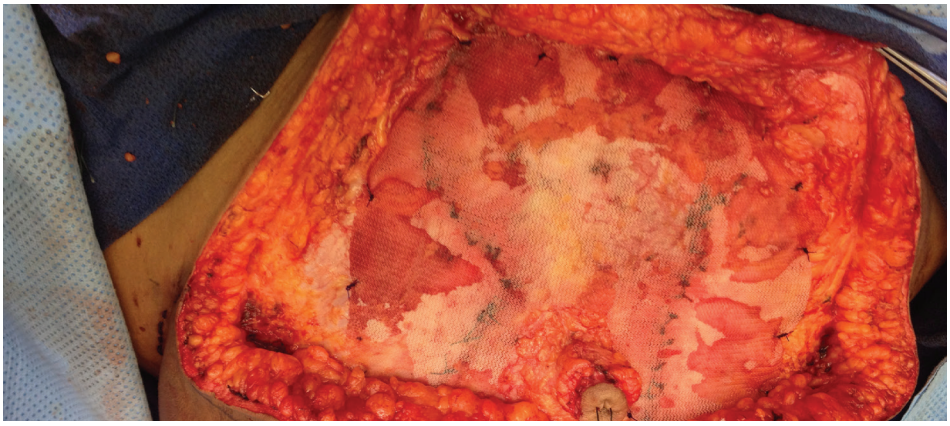
Onlay placement



Phasix™ Mesh placed in an onlay position, two weeks post implantation.

Photo courtesy of
Gary Anthone, MD
Methodist Bariatric, Omaha, NE

TRAM and DIEP reinforcement



Phasix™ Mesh reinforcing the abdominal wall after autologous breast reconstruction.

Photos courtesy of
Mark L. Venturi, MD, FACS
Georgetown University Medical Center

Phasix™ Mesh

- Phasix™ Mesh is a knitted monofilament mesh scaffold made of Poly-4-hydroxybutyrate (P4HB), a biologically derived, fully resorbable material.
- It allows for the assembly of new collagen around a macroporous scaffold, which resorbs slowly over time and is replaced with new host collagen.
- Its monofilament design provides a well-defined host response.
- Predictably resorbed through hydrolysis, P4HB metabolizes into biocompatible byproducts, CO_2 and H_2O.

Indications. Phasix™ Mesh is indicated to reinforce soft tissue where weakness exists in patients undergoing plastic and reconstructive surgery, or for use in procedures involving soft tissue repair, such as the repair of hernia or other fascial defects that require the addition of a reinforcing or bridging material to obtain the desired surgical result. **Contraindications.** Because Phasix™ Mesh is fully resorbable, it should not be used in repairs where permanent wound or organ support from the mesh is required. **Warnings.** 1. Phasix™ Mesh must not be put in direct contact with bowel or viscera. 2. Device manufacture involves exposure to tetracycline hydrochloride and kanamycin sulfate. The safety and product use for patients with hypersensitivities to these antibiotics is unknown. Use of this device in susceptible patients with known allergies to tetracycline hydrochloride or kanamycin sulfate should be avoided. 3. The safety and effectiveness of Phasix™ Mesh in the following applications has not been evaluated or established: a. Pregnant women. b. Pediatric use. c. Neural and cardiovascular tissue. 4. If an infection develops, treat the infection aggressively. Consideration should be given regarding the need to remove the mesh. An unresolved infection may require removal of the device. 5. To prevent recurrences when repairing hernias, the Phasix™ Mesh must be large enough to provide sufficient overlap beyond the margins of the defect. Careful attention to mesh fixation placement and spacing will help prevent excessive tension or gap formation between the mesh and fascial tissue. **Adverse reactions.** In preclinical testing, Phasix™ Mesh elicited a minimal tissue reaction characteristic of foreign body response to a substance. The tissue reaction resolved as the mesh was resorbed. Possible complications may include, but are not limited to infection, seroma, pain, mesh migration, wound dehiscence, hemorrhage, adhesions, hematoma, inflammation, allergic reaction, extrusion, erosion, fistula formation and recurrence of the hernia or soft tissue defect.

Please consult package insert for more detailed safety information and instructions for use.

Product codes

Prodoct code	Qty.	Shape	Dimensions
1190100	1/cs	Round	3" *(7.6 cm)*
1190011	1/cs	Round	4.5" *(11 cm)*
1190808	1/cs	Square	3" x 3" *(8 cm x 8 cm)*
1190616	1/cs	Rectangle	2.4" x 6.3" *(6 cm x 16 cm)*
1190816	1/cs	Rectangle	3" x 6.3" (8 *cm* x 16 cm)
1190820	1/cs	Rectangle	3" x 8" *(8 cm x 20 cm)*
1191010	1/cs	Square	4" x 4" *(10 cm x 10 cm)*
1190200	1/cs	Rectangle	4" x 6" *(10.2 cm x 15.2 cm)*
1191020	1/cs	Rectangle	4" x 8" *(10 cm x 20 cm)*
1191025	1/cs	Rectangle	4" x 10" *(10 cm x 25 cm)*
1190300	1/cs	Rectangle	6" x 8" *(15.2 cm x 20.3 cm)*
1191525	1/cs	Rectangle	6" x 10" *(15 cm x 25 cm)*
1192020	1/cs	Square	8" x 8" *(20 cm x 20 cm)*
1191530	1/cs	Rectangle	6" x 12" *(15 cm x 30 cm)*
1190400	1/cs	Rectangle	8" x 10" *(20.3 cm x 25.4 cm)*
1192030	1/cs	Rectangle	8" x 12" *(20 cm x 30 cm)*
1192040	1/cs	Rectangle	8" x 16" *(20 cm x 40 cm)*
1190500	1/cs	Rectangle	10" x 12" *(25.4 cm x 30.5 cm)*
1193030	1/cs	Square	12" x 12" *(30 cm x 30 cm)*
1192540	1/cs	Rectangle	10" x 16" *(25 cm x 40 cm)*
1193045	1/cs	Rectangle	12" x 18" *(30 cm x 45 cm)*
1193535	1/cs	Square	14" x 14" *(35 cm x 35 cm)*
1194040	1/cs	Square	16" x 16" *(40 cm x 40 cm)*
1194545	1/cs	Square	18" x 18" *(45 cm x 45 cm)*
1195050	1/cs	Square	19.5" x 19.5" *(50 cm x 50 cm)*

1. Preclinical data on file. Results may not correlate to clinical performance in humans. **2.** Usher FC. Hernia repair with knitted polypropylene mesh. *Surg Gynecol Obstet.* 1963 Aug;117:239-40. **3.** Itani KM, Rosen M, Vargo D, et al. Prospective study of single-stage repair of contaminated hernias using a biologic porcine tissue matrix: the RICH Study. *Surgery.* 2012 Sep;152(3):498-505. **4.** Sanchez Vivian M., Youmna E. Abi-Haidar, Itani Kamal MF. Mesh infection in ventral incisional hernia repair: incidence, contributing factors, and treatment. *Surg Infect.* 2011 Jun;12(3):205-10. **5.** Harth KC, Blatnik JA, Anderson JM, Jacobs MR, Zeinali F, Rosen MJ. Effect of surgical wound classification on biologic graft performance in complex hernia repair: an experimental study. *Surgery.* 2013 Apr;153(4):481-92. **6.** IMS, Q2 2014. **7.** Internal market research, data on file. 2014. **8.** Deeken CR, Abdo MS, Frisella MM, Matthews BD. Physicomechanical evaluation of absorbable and nonabsorbable barrier composite meshes for laparoscopic ventral hernia repair. *Surg Endosc.* 2011 May;25(5):1541-52. **9.** Estimated from Standard Curve in Martin DP, et al. Characterization of poly-4-hydroxybutyrate mesh for hernia repair applications. *J Surg Res.* 2013 Oct;184(2):766-73. **10.** Nguyen PT, Asarias JR, Pierce LM. Influence of a new monofilament polyester mesh on inflammation and matrix remodeling. J Invest Surg. *2012* Oct;25(5):330-9. **11.** Bryan N, Ahswin H, Smart NJ, Bayon Y, Hunt JA. In vitro activation of human leukocytes in response to contact with synthetic hernia meshes. *Clin Biochem.* 2012 Jun;45(9):672-6. **12.** Aydinuraz K, Ağalar C, Ağalar F, Ceken S, Duruyürek N, Vural T. In vitro S. epidermidis and S. aureus adherence to composite and lightweight polypropylene grafts. *J Surg Res.* 2009 Nov;157(1):e79-86. **13.** Amid PK, Shulman AG, Lichtenstein IL, Hakaha M. Biomaterials for abdominal wall hernia surgery and principles of their applications. *Langenbecks Arch Chir.* 1994;379(3):168-71. **14.** Klinge U, Junge B, Spellerberg B, Piroth C, Klosterhalfen B, Schumpelick V. Do multifilament alloplastic meshes increase the infection rate? Analysis of the polymeric surface, the bacterial adherence, and the in vivo consequences in a rat model. *J Biomed Mater Res.* 2002;63(6):765-71. **15.** Halaweish I, Harth K, Broome AM, Voskerician G, Jacobs MR, Rosen M. Novel in vitro model for assessing susceptibility of synthetic hernia repair meshes to Staphylococcus aureus infection using green fluorescent protein-labeled bacteria and modern imaging techniques. *Surg Infect (Larchmt).* 2010 Oct;11(5):449-54. **16.** Blatnik A, Krpata D, Jacobs M, Gao Y, Novitsky Y, Rosen M. In vivo analysis of the morphologic characteristics of synthetic mesh to resist MRSA adherence. *J Gastrointest Surg.* 2012 Nov;16(11):2139-44. **17.** Ceydeli A, Rucinski J, Wise L. Finding the best abdominal closure: an evidence-based review of the literature. *Curr Surg.* 2005 Mar-Apr;62(2):220-5. **18.** Deeken CR, Matthews BD. Characterization of the mechanical strength, resorption properties, and histologic characteristics of a fully absorbable material *(Poly-4-hydroxybutyrate-PHASIX Mesh)* in a porcine model of hernia repair. *ISRN Surg.* 2013 May 28;2013:238067. **19.** Katz AR, Mukherjee DP, Kaganov AL, Gordon S. A new synthetic monofilament absorbable suture made from polytrimethylene carbonate. *Surg Gynecol Obstet.* 1985 Sep;161(3):213-22. **20.** Chu CC. The effect of pH on the in vitro degradation of poly(glycolide lactide) copolymer absorbable sutures. *J Biomed Mater Res.* 1982 Mar;16(2):117-24. **21.** LeBlanc, Karl A. Repair of Umbilical Hernias with a Resorbable Synthetic Mesh. Clinical experience document for informational purposes only. The results may not be predictive for all patients. BD. document number MMPMCR1. **22.** Phasix™ Mesh Instructions for Use, PK3799200

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