7 Prostheses and Products for Hernioplasty

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Introduction

The use of prosthetic biomaterials in the repair of hernias of the abdominal wall is now very commonplace throughout the world. In the USA over 95% of all inguinal and ventral hernias are repaired with a prosthetic material or device and some countries are also beginning to approach this figure. In other parts of the world, this is not the case. Limitations on the use of these products include a natural reluctance to place a biomaterial into a primary hernia or the cost of these products. Increasing usage of these products has increased due to the fact that recurrence rates are markedly decreased with their use (this is described in other chapters in this text).

Incisional hernias will develop in at least 13% and perhaps as many as 20% of laparotomy incisions. The risk of herniation is increased by fivefold if a postoperative wound infection occurs. Other factors that predispose to the development of a fascial defect include smoking, obesity, poor nutritional status, steroid usage, etc. While some of these may be avoided, those patients that are found to have such a hernia can present difficult management problems due to the high potential for recurrence. It has been known for many years that without the use of a prosthetic material, the recurrence rate for ventral hernia repair is as high as 51% [1]. The use of a synthetic material will reduce this rate to 10–24% [2]. While these publications are older, they are still relevant in today's management of hernia repair. Recent data still reveals a recurrence rate of 17.1% without the use of mesh, 12.3% with open mesh repair and 10.6% with laparoscopic mesh repair [3].

The laparoscopic repair of incisional and ventral hernias was first performed in 1991 using the Soft Tissue Patch made by W.L. Gore and Associates (Elkhart, DE, USA) [4]. The recurrence rate that has been reported in other recent literature varies from 0–11% but averages approximately 5.5%. The "ideal" prosthetic product has yet to be found. The hernia that is being repaired and the status of the patient into which this material will be placed should dictate the type of material that will be chosen. This chapter will identify these goals and the properties of the various biomaterials that are on the market today.

There are several hundred different products that can be used in the repair of inguinal, ventral, incisional and other hernias of the abdominal wall. In many of the products listed below there is a paucity of published literature that verifies the claims that are made by the manufacturers. It is very difficult to find Level 1 studies that evaluate the success or failure of the respective materials. While this is the situation at the time of the production of this textbook, the reader is advised to reference the available journals to identify the uses and results of these materials. Much of the information discussed was obtained from the respective manufacturer directly but not in all cases. Therefore, the reader should reference the particular manufacturer for in-depth information that cannot be provided in this text.

Indications for Use of Prosthetic Materials

Surgeons recognize that the main purpose in the use of these materials will be the repair of a fascial defect in the abdominal wall. The main indications of use of the materials are listed in Table 7.1.

Musculofascial tissue strength can be lost in a variety of ways. The most common, of course, would be due to the external etiology of the weakness that develops after a laparotomy or other abdominal incision that is larger than that of the 5 mm laparoscopic trocar (although even this small incision can rarely develop a hernia). Another example would be the loss of tissue with trauma such as gunshot wounds and/or treatment with an open abdomen. The increase of intra-abdominal pressure that results from sig-

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Table 7.1 Indications for prostheses

Replacement of lost musculofascial tissue caused by:
Trauma
External
Internal
Infection
Reinforcement of native tissue weakness
Aging (laxity of tissues)
Neurological deficit (denervation)

Table 7.2 Natural prosthetic products

Autogenous dermal grafts	Whole skin grafts
Dermal collagen homografts	Porcine dermal collagen
Autogenous fascial heterografts	Lyophilized aortic homografts
Preserved dural homografts	Bovine pericardium

Table 7.3 Nonmetallic synthetic products

Fortisan fabric (cellulose)	Polytetrafluoroethylene
Polyvinyl sponge	Polypropylene mesh/gelatin film
Polyvinyl cloth	Polyester-reinforced silicon sheeting
Nylon mesh	Silastic
Carbon fiber	Polyester (as a solid sheet)
Silicon-velvet composite	Carbon fiber

nificant weight gain will result in an internal source of weakening of the abdominal wall musculature. Poor nutrition and/or protein malnutrition are also sources of such problems. Other pre-disposing factors such as emphysema or the chronic bronchitis of individuals that smoke tobacco products result in a constant increase in intra-abdominal pressure because of a frequent cough. Life-threatening infections such as fasciitis and gangrene will produce large areas of necrosis and resultant tissue loss. More frequently, the development of a postoperative wound infection will increase the risk of herniation by as much as five times. In fact, almost 30% of patients that develop a postoperative incisional wound infection will eventually develop an incisional hernia [5]. Modern needs of patients have resulted in the development of products that are not permanent such as biologic meshes or synthetic products that resorb over varying lengths of time.

The effects of aging and the declining ability of the elderly patients to repair the native tissues will lead to the loss of fascial integrity. This is commonly seen with the direct inguinal hernia. It also occurs with the enlargement of the linea alba that is referred to as diastasis recti. These latter defects can enlarge and occasionally become symptomatic, requiring repair. The disruption of collagen that is seen by the effects of smoking will have a similar effect (i.e., metastatic emphysema).

The most common defect that results from a denervation phenomenon follows the flank incision that is utilized in a nephrectomy, lumbar sympathectomy, or an anterior approach to the lumbar interbody fusion for degenerative disc disease. In these entities, there is no defined fascial edge that is seen with the more common anterior abdominal wall defects. This is due to the broad surface of the denervated musculature that has intact fascia but lacks the reinforcement of healthy muscle tissue. These are very challenging to repair and such methods are described elsewhere in this textbook. Mesh materials are necessary for these problems to assure as durable a repair as feasible.

Prosthetic Materials: History

The use of materials for the repairs of hernias can be found in antiquity. It is believed that Heliodorus used cellulose from a cotton or flax plant to effect scarification in the inguinal area to treat herniation in A.D. 25. The use of silver as a synthetic prosthesis was reported in 1900 [6]. Metallic biomaterials have also included the use of tantalum gauze mesh and stainless steel mesh. None of these materials gained wide acceptance because of the complications that were associated with their usage. These included lack of pliability, seroma development, wound infection, fatigue fractures, herniation through the fracture sites, abnormal scarification, adhesions, loss of structural integrity, and allergic reactions. Re-operation in these patients was particularly challenging.

Natural prostheses were considered as myofascial replacement shortly after the use of silver filigree [7]. Other materials that have been used are listed in Table 7.2.

These materials were used with good results in some cases but scarcity and cost limited their widespread adoption. Additionally, there were concerns of viral transmission as one case of Creutzfeldt-Jacobs disease developed in a patient that had the use of a dural homograft. The development of other synthetic biomaterials that were closer to the ideal prosthesis hastened the demise of the use of these products in the past. As we now have seen over the last several years, some of these products have seen resurgence. Updated methods of processing these products have allowed for improved safety and efficacy resulting in an expansion of their use. The use of these biological products is still undergoing careful scrutiny for the most appropriate application of these expensive materials.

A series of nonmetallic synthetic prosthetic biomaterials were used as well (Table 7.3). As with the metal materials, there were significant disadvantages with these products also. These included infections, sinus tract formation, alteration of the product in vivo, and lack of incorporation into the native tissues. The use of the carbon fiber in humans has never been attempted because of concerns of potential carcinogenicity (although it functioned fairly well in the experi-

Table 7.4 Ideal characteristics of synthetic products

No physical modification by tissue fluids	Chemically inert
Does not incite inflammatory or foreign body reaction	Does not produce allergy or hypersensitivity
Noncarcinogenic	Resistant to mechanical strains
Can be fabricated to the form required	Sterilizable

Table 7.5 Ideal surgical clinical characteristics of synthetic products

Permanent repair of the abdominal wall (i.e., no recurrences)
In-growth characteristics that result in a normal pattern of tissue repair and healing
No alteration of the compliance of the abdominal wall musculature
Lack of adhesion predisposition
Cuts easily and without fraying
Inexpensive
Lack of long-term complications such as pain or fistualization

mental model). With some of these materials, newer hernia repair products have used these materials again because of more modern manufacturing capabilities.

All of these biomaterials were attempting to address the "ideal characteristics" that were promulgated by Cumberland and Scales [8, 9]. While it is widely felt that the ideal material has yet to be found, these criteria are the goals that are sought by the manufacturers (Table 7.4).

While the clinical uses of these prosthetic materials share these considerations, the operating surgeon does, in fact, desire slightly different priorities in the use of the prosthesis within his or her individual patient. Disregarding the obvious need to be non-carcinogenic, the clinical characteristics of the "ideal surgical" material are listed in Table 7.5.

Biologic prostheses are based upon the use of porcine, bovine, or cadaveric tissues to produce a collagen matrix. These materials are not truly absorbable as they are intended to provide a scaffold for the native fibroblasts to incorporate natural collagen to repair a fascial defect. It is the goal of these devices to repair the hernia defect with the tissues of the patient as these will be degraded and replaced over time.

The synthetic prosthetic materials can be divided into the absorbable and non-absorbable products. The synthetic non-absorbable materials are of many types, sizes, and shapes. The use of these products is commonplace in the repair of virtually all hernias. There has been an increase in the number of synthetic absorbable products over the last several years. More recently there are hybrid products that include both absorbable and non-absorbable layers. These attempt to capitalize on the attributes of both of these technologies.

The materials that are presented below are given in an arbitrary arrangement and with as accurate information that could be obtained. An effort was made, however, to stratify these products in a classification that grouped similar products together. I have attempted to identify all of the currently available products that are used in most parts of the world at the time of publication. Some of these materials have either no published clinical data or scant information as to the clinical performance characteristics. Therefore, it is certain that some products and/or details have been overlooked despite my efforts to present all that I could identify. Due to the very large variation in the sizes of the products, little comment regarding the sizes of these products will be given. The reader is referred to the respective manufacturer for these details. It should also be noted that not all of these products are available in all countries. Manufacturers have limited the release of many of them to only selected areas of the world or have not obtained the necessary governmental approvals for clinical distribution at the time of this writing. Finally, it is certain that all of the available products are not included in this compilation or that some of those listed are no longer available due to the lag in this research and actual publication. Many companies are quite small and/or have limited distribution. Therefore, if any of these that are not included it was not because of an intended omission but rather a lack of obtainable information.

Absorbable Prosthetic Biomaterials

The general purpose of these is the temporary replacement of absent tissue (Table 7.6). The strength of these materials and the lack of permanency make some of them unsuitable for the permanent repair of any hernia. The newer research has suggested that this materials might be preferred in some circumstances rather than a true biologic. This may be due to the fact that biologics require degradation then rebuilding of the collagen of the patient's fascia. These materials do not require the extent of cellular degradation that true biological

Table 7.6 Absorbable products

Bio-A, W. L. Gore & Associates, Elkhart, DE
Bio-A Hernia Plug, W. L. Gore & Associates, Elkhart, DE
Dexon, Medtronic, Minneapolis, MN, USA
Safil Mesh, B. Braun Surgical, Germany
TIGR mesh, Novus Scientific Pte Ltd, Singapore
Phasix mesh, CR Bard, Providence, RI, USA
Phasix mesh Plug and Patch, CR Bard, Warwick, RI, USA
Phasix ST mesh, CR Bard, Providence, RI, USA
Vicryl (knitted) mesh, Ethicon, Inc., Somerville, NJ, USA
Vicryl (woven) mesh, Ethicon, Inc., Somerville, NJ, USA

materials require and seem to progress to reconstructive metabolism more rapidly. This is an area of ongoing research. Clinical usage will be dependent upon the longevity of the material that is sought by the surgeon.

Bio-A, *Phasix*, and *TIGR* meshes represent a somewhat newer concept in synthetic materials. This field of materials perhaps represents part of the next phase of mesh development. As will be seen below, combination products have now been developed with a permanent backbone and the absorbable materials listed here. The *Bio-A* product is supplied in flat sheets (Fig. 7.1). It is made of trimethylene carbonate and polyglycolic acid. It will maintain approximately 70% of its tensile strength for 21 days. It serves as a scaffold to allow for fibroblastic infiltration and replacement by the patient's native collagen. Recent studies have shown efficacy for complex situations [10]. It can be used in inguinal, incisional, and hiatal hernia repair. The latter is specifically configured for that use. This material is also configured into the *Bio-A Hernia Plug* (Fig. 7.2). This configuration can be used in the groin, umbilical or ventral hernia repair.

Fig. 7.1 Bio-A

Fig. 7.2 Bio-A hernia Plug

Safil Mesh is a warp-knitted polyglycolic acid material that will retain 50% of its strength at 20 days and is totally resorbed in 60–90 days (Fig. 7.3). It is used to strengthen the closure of the abdominal and chest walls. The above photo also shows the bags into which this material is also shaped for use in splenic preservation.

Phasix is composed of poly-4-hydroxybutyrate (P4HB). This is produced from by-products of E. coli metabolism (Fig. 7.4). It is degraded by hydrolysis and hydrolytic enzymatic processes. The absorption of the material is minimal until about 26 weeks post-implantation and is essentially complete in about 52 weeks. The Phasix has been configured into a plug similar to the Perfix plug and patch (Fig. 7.5). Its use is similar to that device except that

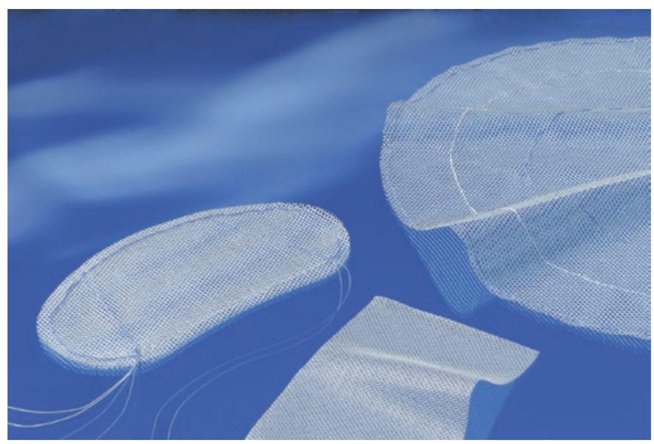

Fig. 7.3 Safil mesh

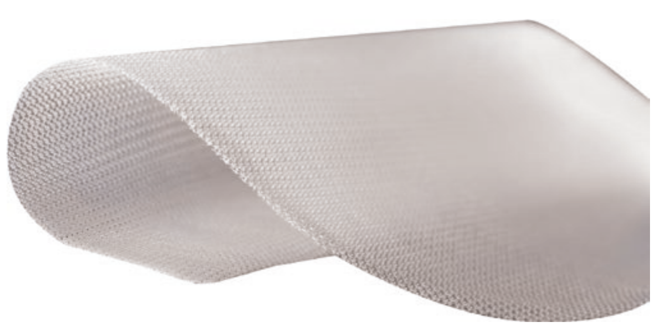

Fig. 7.4 Phasix

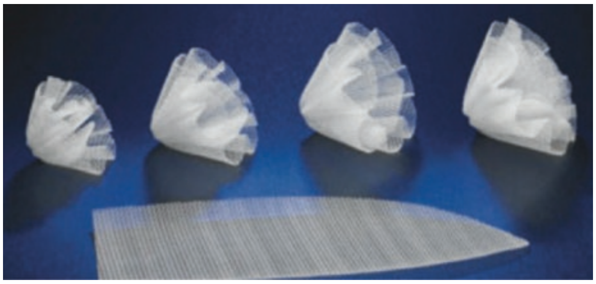

Fig. 7.5 Phasix plug and patch

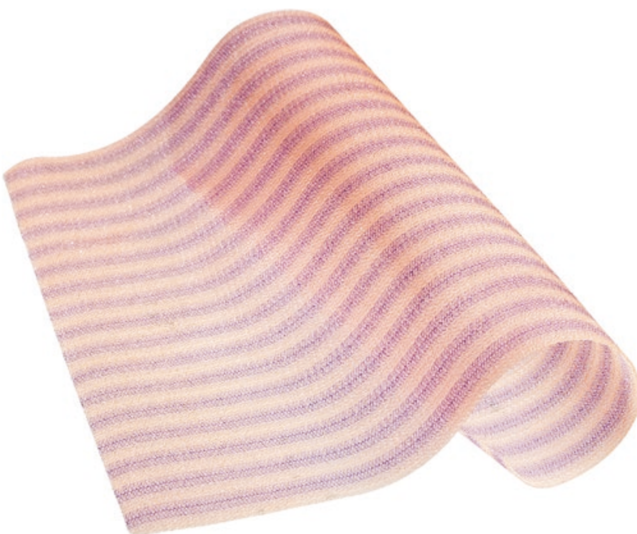

Fig. 7.6 Phasix ST

it is not permanent. The flat mesh is also available with a barrier coating of carboxymethylcellulose and hyaluronic acid as Phasix ST (Fig. 7.6). This product is placed in the intraperitoneal position against the intestine. There are many investigations that are ongoing to learn the unique properties of this product.

TIGR Matrix Surgical Mesh is knitted from two different synthetic resorbable fibers, polyglycolic acid and polylactic acid (Fig. 7.7). The Matrix is warp-knitted in a proprietary way, allowing it to gradually degrade over time. The strength of the Matrix is comparable to conventional mesh implants for the initial 6–9 months following implantation. The first fiber (polyglycolic acid) appears to lose its functional capabilities in 2 weeks while the second fiber (polylactic acid) maintains its strength for approximately 9 months.

The *Vicryl* and *Dexon* meshes are primarily polylactic acid (Figs. 7.8 and 7.9). The Vicryl is available in a knitted or woven configuration as noted in the figure. These products can be affixed onto the fascia directly with sutures but are not

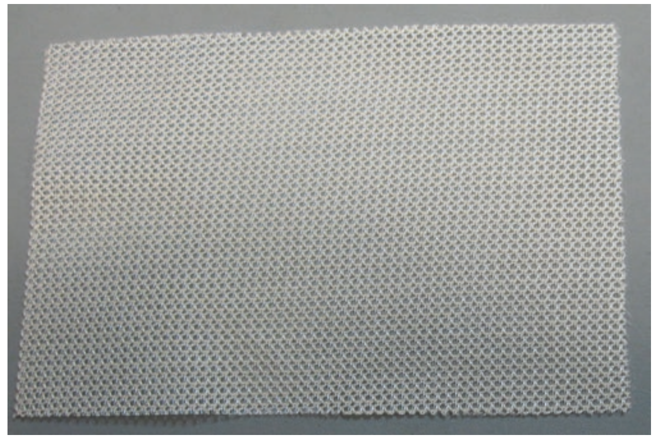

Fig. 7.7 TIGR matrix surgical mesh

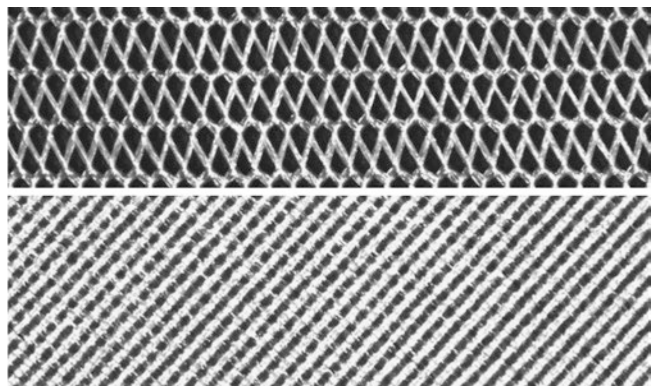

Fig. 7.8 Vicryl knitted (upper) & woven (lower) (Image courtesy of Ethicon, Inc.)

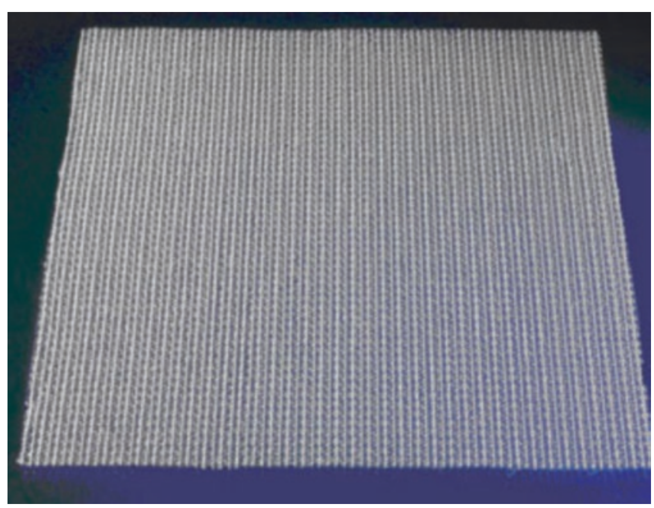

Fig. 7.9 Dexon mesh (All rights reserved. Used with Permission of Medtronic)

Biologic Products

As noted earlier, these products do not represent a new concept in hernia repair. They are marked improvement of the materials developed earlier in the last century. They are based upon a harvested collagen matrix that is manufactured into sheets of tissue-engineered materials that can be used to repair defects in the abdominal wall. The concept of these materials is that the biologic material will allow the migration of the patient's own fibroblasts onto them so that collagen will be deposited to form a "neo-fascia." For the most part, these are used in open techniques but there has been some usage in laparoscopic methods especially in the repair of hiatal hernias.

There are similarities of all of the biologic products. They are the most expensive of all prosthetic materials that repair or replace the abdominal wall fascia. They are all harvested from an organism that was once alive. The source will dictate the size of the material and in most cases, the thickness of the product. The thickness will be variable in nearly all of them. Some manufacturers have found creative techniques to increase the size of the materials available. All of the products are processed to eliminate all cellular and nuclear material as well as any prions. Following this, another process can be applied to crosslink the collagen at the molecular level. There is only one product that is currently cross-linked as discussed below. The final stage is the sterilization of the prosthesis. It is beyond the scope of this chapter to cover all of these in detail. However, it should be considered, when using any of these materials, that the processing plays a large part into the characteristics and the clinical behavior of them post-implantation.

In general, the biologic products were introduced for use in contaminated fields such as a synthetic mesh infection. While they can be used in this manner, it is recommended that the wound should not possess gross pus as the collagenases of some bacteria and inflammatory cells can degrade these products. These products are sometimes used in the repair of very complex non-infected hernias as well. One concern will be that if the patient possesses an undiagnosed collagen deficiency disorder, the remodeling of these products will not occur properly, leading to a predictable failure of the repair. It has also been learned over the last few years that these products perform best if they have direct contact with some type of vascularized tissue. Intuitively, if the expectation of these biologic scaffolds to become infiltrated by fibroblasts and subsequent collagen deposition, blood supply will deliver these cells more rapidly. Consequently, a higher failure rate will be noted if a biologic prosthesis is used as a "bridge" between fascial edges. It is recommended that if a bridge is unavoidable, then use of the peritoneum of the hernia sac can provide a source of vascular supply.

Bovine Products

The bovine products are from dermis or pericardium (Table 7.7). Only the *SurgiMend* is fetal (dermal) tissue (Fig. 7.10). As shown in the figure, it is available in four different sizes. The associated numbers are the thickness of the four different products in millimeters. *SurgiMend-e* is specifically designed for ventral hernia repair (Fig. 7.11). It is elliptical in shape, perforated and available in 3 mm or 4 mm thicknesses. *SurgiMend MP* is similar to the former product in that it is available in four different thicknesses but is also perforated over its entirety (Fig. 7.12).

Tutomesh and *Tutopatch* are of the same source (pericardium) and are processed in the same manner (Figs. 7.13 and 7.14). The only difference in these two is that the Tutomesh is perforated while Tutopatch is not. *Veritas* is also pericardium and does not require rehydration

Table 7.7 Bovine biologic prostheses

SurgiMend 1.0,2.0,3.0,4.0, Integra LifeSciences, USA
SurgiMend-e, Integra LifeSciences, USA
SurgiMend MP, Integra LifeSciences, USA
Tutomesh, RTI Biologics, Alachua, FL, USA
Tutopatch, RTI Biologics, Alachua, FL, USA
*Veritas*s, Baxter Healthcare Corporation, Deerfield, IL USA

Fig. 7.10 SurgiMend 1.0–4.0

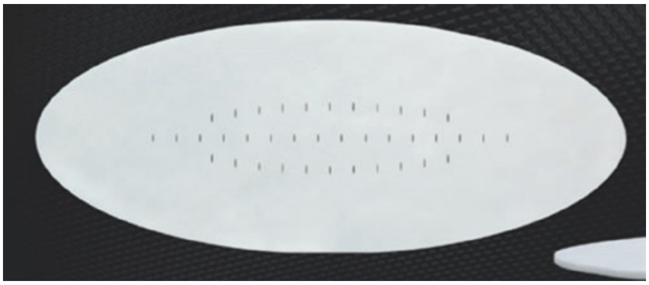

Fig. 7.11 SurgiMend-e

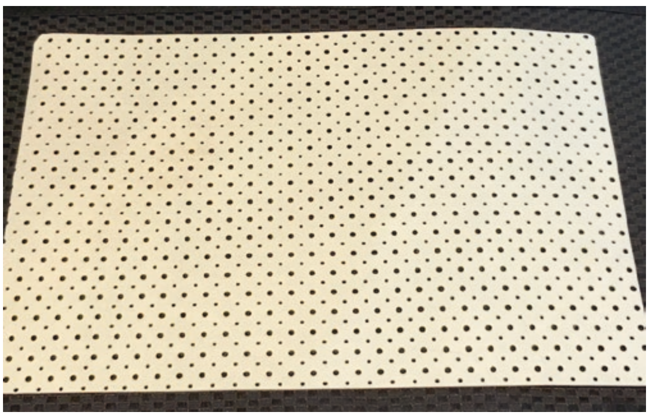

Fig. 7.12 SurgiMend MP

(Fig. 7.15). The use of all of these bovine products has generally been limited to the incisional hernia repair. However there has been increasing application in the repair of hiatal hernias.

Cadaveric Products

The human cadaveric products have a long history (Table 7.8). There is significant variability in the amount of stretch that each of these will undergo either at the time of implantation or subsequent to the procedure. This stretch varies from product to product and should be accounted for at the time of implantation. These products are not cross-linked and require rehydration. These are also used in the repair of hiatal hernias. *AlloMax* Surgical Graft is 0.8–1.8 mm thick (Fig. 7.16). *Cortiva* and *Cortiva 1 mm* are similar materials that are in two different thicknesses. *Cortiva* is thicker at 1.3 mm (0.8–1.8 mm) and

Fig. 7.13 Tutomesh

Fig. 7.14 Tutopatch

Fig. 7.15 Veritas

Cortiva 1 mm is 1 mm (0.8–1.2 mm) (Fig. 7.17). *DermaMatrix* is used for hernia repair but is additionally used for purposes other than hernia repair (Fig. 7.18). It is available in thicknesses of 0.2–0.4 mm, 0.4–0.8 mm, 0.8–1.7 mm, and ≥1.8 mm. It is notched so that if the notch is in the upper left the epidermal side (basement membrane) is facing up. It is recommended that the dermal side be placed against vascularized tissue. *Flex HD Structural* is available in a thick version (0.8–1.7 mm) or an Ultra Thick version (1.8–4 mm). The Musculoskeletal Transplant Foundation produces the latter two products (Fig. 7.19).

Porcine Products

There are a number of these materials that are available (Table 7.9). Depending on the manufacturer, they are in different sizes and shapes and construction. Some are laminated, some are cross-linked, some are perforated, some require rehydration and others do not. These are specific to the product and it is recommended that the user follow the instructions for use (IFU) that is provided with each product.

BioDesign Hernia Grafts are three products that are designed for the repair of specific hernias, ventral, inguinal, and hiatal (Figs. 7.20, 7.21, and 7.22). They are all developed from porcine small intestinal submucosa and are the only products with such a source. These are laminated, sewn together, and fenestrated. These must be rehydrated. *Cellis* is porcine dermal collagen and is available in many sizes and different thicknesses (Fig. 7.23). It also requires rehydration. *Fortiva* originates from dermis but does not require hydration (Fig. 7.24). *Gentrix Surgical Matrix* is also a laminated product. It is unique in this biologic category as it is the only one that is made from the urinary bladder of the pig. All of these

Table 7.8 Cadaveric biologic prostheses

AlloMax, Davol, Inc., Warwick, RI, USA
Cortiva, RTI Surgical, Alachua, FL, USA
Cortiva 1mm, RTI Surgical, Alachua, FL, USA
DermaMatrix, Synthes CMF, West Chester, PA, USA
FlexHD STRUCTURAL, Ethicon, Inc., Somerville, NJ, USA

Fig. 7.16 AlloMax

Fig. 7.17 Cortiva

Fig. 7.18 DermaMatrix

Fig. 7.19 Flex HD structural (Image courtesy of Ethicon, Inc.)

products have a notch to identify the correct positioning of the material. If the notch is placed in the upper top outside corner, then the basement membrane is facing up. The membrane should be placed away from the defect according to the product literature. *Gentrix* is available as *RS* (two ply), *PSM* (three ply), *PSMX* (six ply), or Plus (8 ply), (Figs. 7.25, 7.26, 7.27, and 7.28). *Permacol* is a dermal collagen based product that is the only material listed that is cross-linked and does not require rehydration (Fig. 7.29). It is known to be present for a prolonged period of time due to the cross-linkage of the collagen fibers. It is available in thicknesses of 0.5, 1.0, and 1.5 mm.

Table 7.9 Porcine biologic prostheses

Biodesign, Cook Surgical, Inc., Bloomington, IN, USA
Cellis, Meccellis Biotech, La Rochelle, France
Fortiva, RTI Biologics, Alachua, FL, USA
Gentrix Surgical Matrix, ACell, Columbia, MD, USA
Permacol, Medtronic, Minneapolis, MN, USA
Strattice RTM, Acelity, San Antonio, TX, USA
XenMatrix, Davol, Inc., Warwick, RI, USA
XenMatrix AB, Davol, Inc., Warwick, RI, USA
XCM Biologic Tissue Matrix, Ethicon, Somerville, NJ, USA

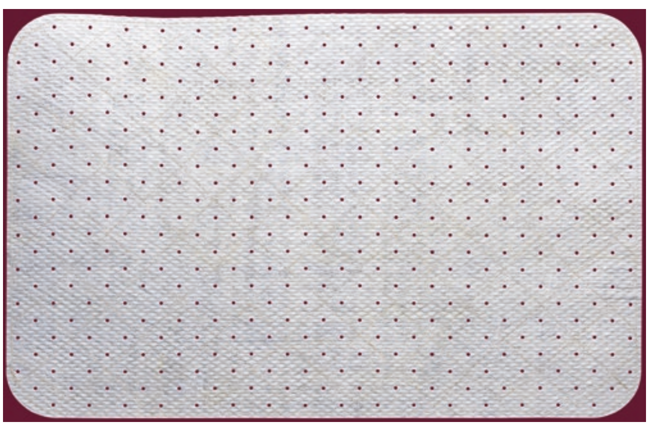

Fig. 7.20 Biodesign hernia graft

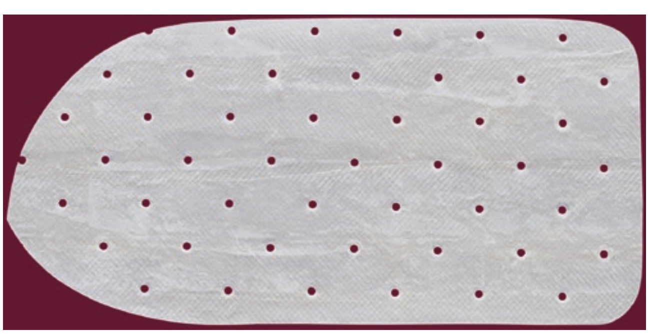

Fig. 7.21 Biodesign inguinal hernia graft

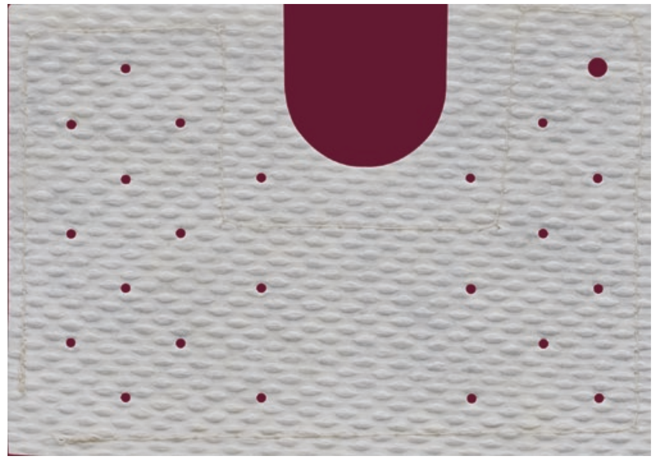

Fig. 7.22 Biodesign hiatal hernia graft

Fig. 7.23 Cellis

Fig. 7.24 Fortiva

Strattice Reconstructive Tissue Matrix (RTM) is available in two thicknesses, firm and pliable. It is made from dermis and does require rehydration. It is available many sizes, which depend upon which version is selected. These versions include a pliable and pre-shaped pliable, a firm (Fig. 7.30), a laparoscopic (Fig. 7.31), and a perforated version (Fig. 7.32). The Strattice Firm has a thickness 1.76 ± 0.012. The selection will depend on type of hernia to be repaired and the area to be covered. *XenMatrix* is also dermal based and is not cross-linked (Fig. 7.33). It does require rehydration but not refrigeration. It is one of the thickest porcine biologics due to its 1.95 ± 0.012 measure-

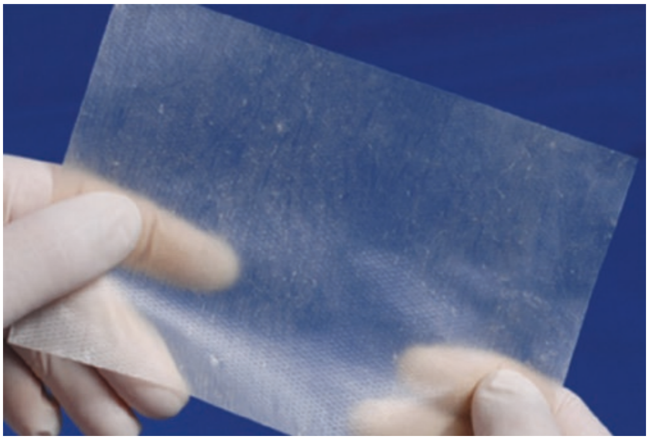

Fig. 7.25 Gentrix RS

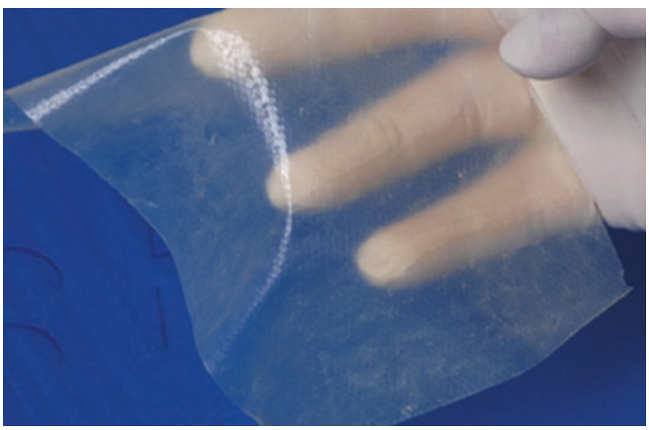

Fig. 7.26 Gentrix PSM

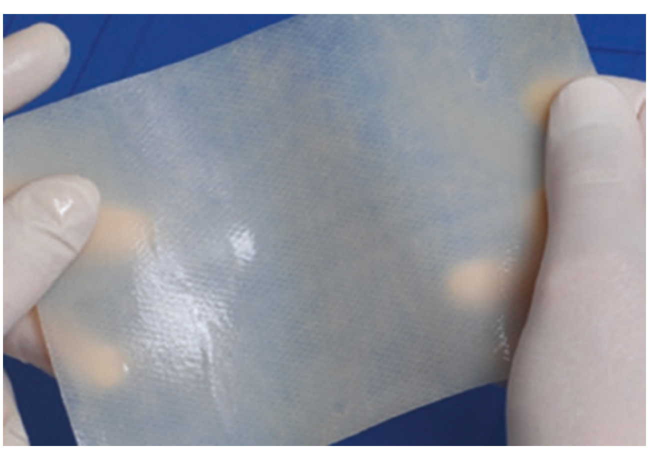

Fig. 7.27 Gentrix PSMX

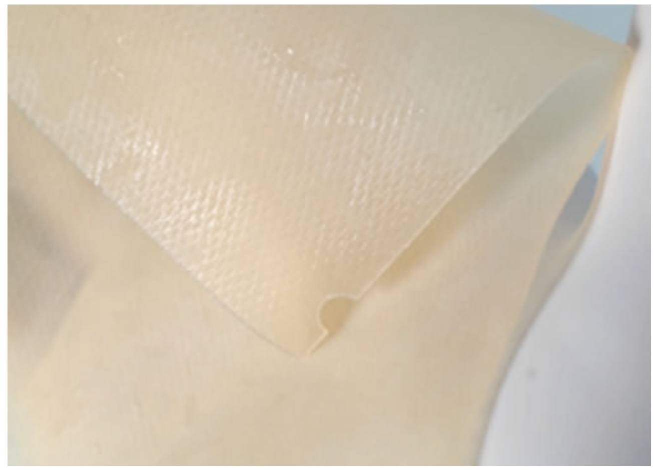

Fig. 7.28 Gentrix plus

Fig. 7.29 Permacol (All rights reserved. Used with Permission of Medtronic)

ment. It has recently been modified to contain the antimicrobials, rifampin and minocycline, which are present for over 7 days. *XenMatrix AB* has a distinct orange color due to the presence of the rifampin (Fig. 7.34). It is unique in all of the biologic materials in that it contains antimicrobial agents. *XCM Biologic Tissue Matrix* is also a non-cross-linked porcine dermal product and does not require rehydration (Fig. 7.35). It is approximately 1.5 mm thick (±0.3 mm).

Hybrid Products

This is a relatively new concept in mesh development. There are clear reasons to use a permanent material in the repair of fascial defects. There are real reasons to consider the use of products that are not permanent but seek to increases the levels of collagen deposition to enhance the healing process. These materials seek to capitalize on the benefits of both of these concepts (Table 7.10). There is relatively little data on

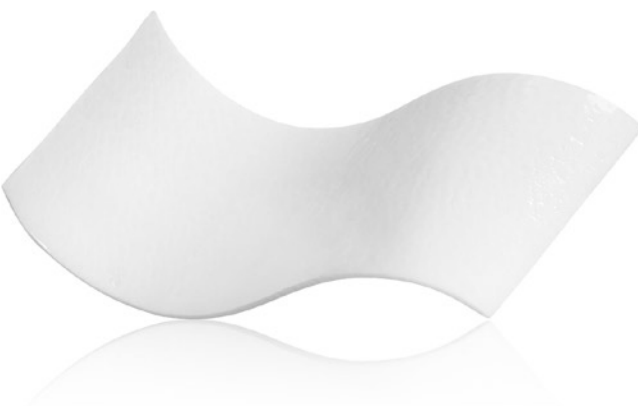

Fig. 7.30 Strattice firm

Fig. 7.31 Strattice laparoscopic

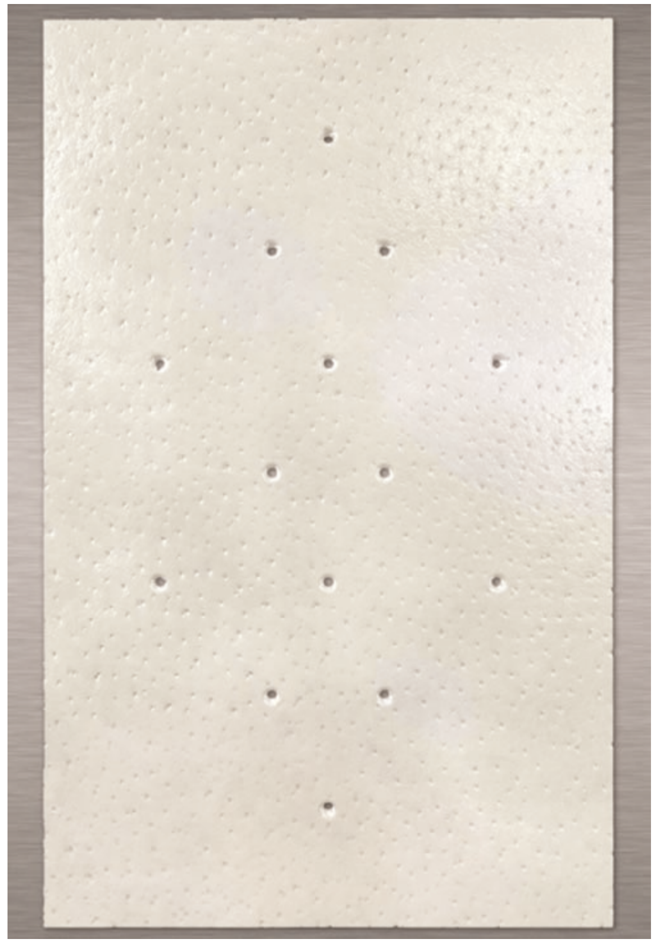

Fig. 7.32 Strattice perforated

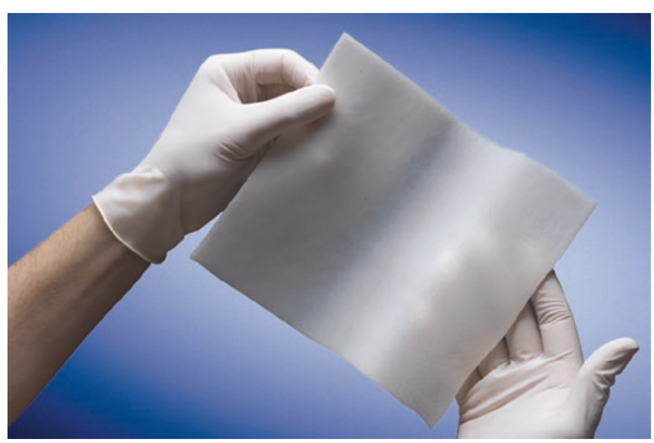

Fig. 7.33 XenMatrix

Fig. 7.34 XenMatrix AB

Fig. 7.35 XCM (Image courtesy of Ethicon, Inc.)

Table 7.10 Hybrid products

OviTex, OviTex 1S, Ovitex 2S, Permanent, TelaBio, Malvern, PA, USA
OviTex, OviTex 1S, Ovitex 2S, Resorbable, TelaBio, Malvern, PA, USA
Synecor, W. L. Gore & Associates, Elkhart, DE, USA
Zenapro, Cook Medical, Bloomington, IL, USA

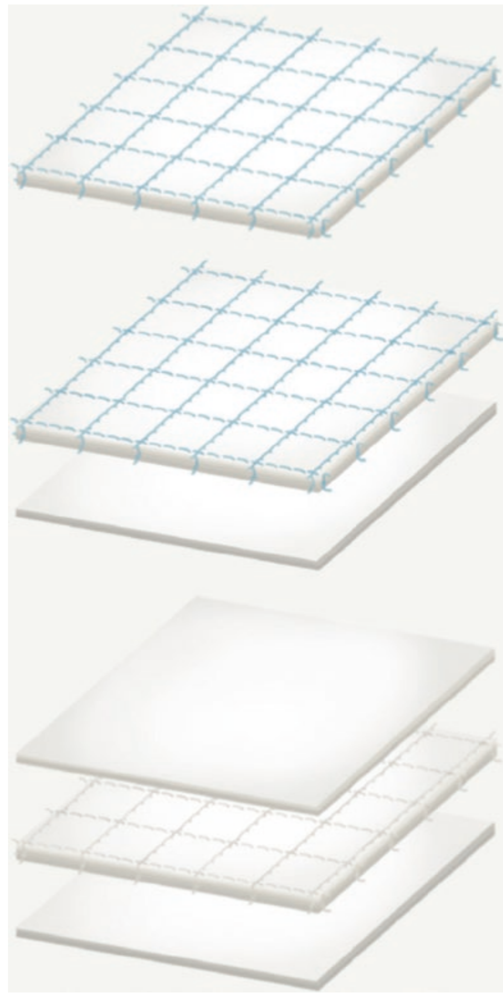

Fig. 7.36 OviTex, 1S, 2S (polypropylene)

the actual results of the use of these materials but these data will undoubtedly be researched in the future.

OviTex, OviTex 1S, and *2S* are the most recent additions to these class of meshes (Fig. 7.36, upper). They are a combination of ovine gastric submucosal extracellular matrix and embedded polypropylene or polyglycolic acid. There is a four-layer core of this matrix in the *OviTex* version. *OviTex 1S* has an additional two layers of matrix on one side *and* the *OviTex 2S* has the core plus two layers on both sides of the product (Fig. 7.36, middle & lower). Because of these differing designs, the thickness varies from 0.9 mm to 1.1 mm to 1.6 mm. The absorbable component option makes it the only biologic hybrid option with such a concept. The non-biologic portion is constructed with 6 mm pores. These figures are of the permanent component option. The resorbable polymer option is clear and will not be seen. Both *OviTex 1S* and *OviTex 2S* can be placed with visceral contact.

Synecor has combined some older materials together (Fig. 7.37). The internal permanent material is polytetrafluoroethylene. This is woven into a structure that is similar to other macroporous materials and is not the same as ePTFE. This is sandwiched between two types of polyglycolic acid/trimethylene carbonate (PGA/TMC). The parietal surface is similar to the Bio-A that is described above (Fig. 7.37, right). The visceral (tissue-separating) side is PGA/TMC and is a different structural weave which is quite tight to prevent ingrowth (Fig. 7.37, left). This material can be used either dry or wet.

Zenapro is the oldest of these three products (Fig. 7.38). It is a combination of the small intestinal submucosa that is found in the BioDesign materials described above. It has two layers of the submucosa on one side and four on the other and is perforated, unlike the other two hybrid products. Between these two layers is a large pore (5 mm) polypropylene mesh. It is not indicated in contaminated fields and requires rehydration. There is a rough and a smooth side with the rough side going against the abdominal wall in the repair of a hernia. The Instructions for Use state "The liberal use of transfascial sutures is recommended. Tacking devices alone may not provide adequate fixation to prevent recurrence."

Fig. 7.37 Synecor

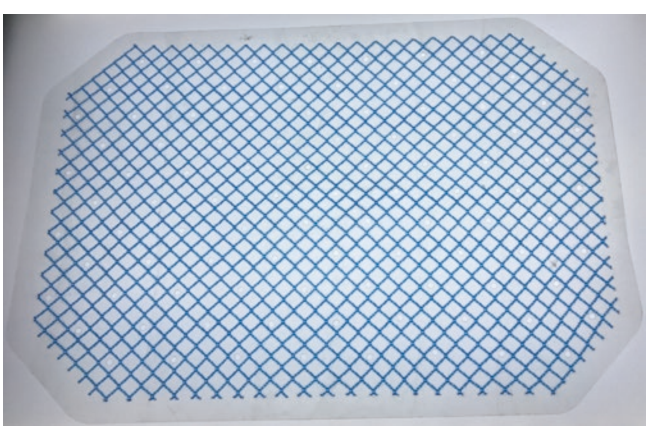

Fig. 7.38 Zenapro

Flat Prosthetic Products

The currently available products in use today are polypropylene (PP), polyester (POL), polytetrafluoroethylene (PTFE), expanded PTFE (ePTFE), or condensed PTFE (cPTFE). All are available in a variety of sizes and can be cut to conform to the dimensions that are necessary. There are currently so many products on the market today that it is quite difficult to become well versed in all of these materials. In fact, the similarities of these materials may result in many of them to be considered a "commodity" type of a product, whereupon only the pricing of the material will influence the use of it. The most prominent and commonly used are PP materials (Table 7.11). These, typically, can be used either in the open or laparoscopic applications (if not exposed to the viscera). Because of the complexities of pore sizes and the multitude of differing weights and shapes of the PPM within each of these materials, this chapter could not expound upon all of them. The reader is referred to the manufacturer for further information in the exact densities, weights, and pore sizes of these products.

The *2D* products are available in a variety of products and weights. The *2D PPT Std* and the *2D PPT LW* are both knitted and differ in the weight and pore size. The former is heavy weight while the latter is medium weight and more macroporous. The 2D PPNT is a non-woven PP material that is available in three different weights and thicknesses (Fig. 7.39). These meshes are configured in a variety of shapes and sizes as shown.

Basic mesh is a lightweight mesh (Fig. 7.40). Di.pro has developed an ultra lightweight version that is called *Basic Evolution* mesh (Fig. 7.41). *Bard Mesh* is probably the oldest flat sheet of heavy weight polypropylene in existence, having been brought to market in the early 1960s (Fig. 7.42). It is still in use today and like many of these prostheses, a lightweight and more macroporous version has been developed, the *Bard Soft Mesh* (Fig. 7.43). *Biomesh P1* (Fig. 7.44) is the standard weight material compared to the *Premium* (Fig. 7.45). It is available for extraperitoneal placement in various shapes and sizes to accommodate open or laparoscopic inguinal and ventral hernias. *Bulev B* and *Bulev UL* are somewhat similar to the Basic and Basic Evolution meshes discussed above (Figs. 7.46 and 7.47). The weights of the Bulev products are 48 gm/m^2 and 39 gm/m^2, respectively. They are different in that they possess blue lines to differentiate them from the other meshes and aid in positioning of the product.

DynaMesh comes in two weights; the standard is twice the weight of the lightweight product (Fig. 7.48). *Easy Prothes* is available as a heavy weight material (90 g/m^2), two medium products (70 and 60 g/m^2), and a lightweight version (40 g/m^2). Figures 7.49, 7.50, 7.51, and 7.52 detail the differences in the weaves of the products. Figures 7.53 and 7.54 compare the medium and lightweight versions. The *Hertra 0* mesh is designed only for use in the open repair of inguinal hernias,

Table 7.11 Flat polypropylene products

2D PPT Std, Microval, Saint-Just-Malmont, France
2D PPT LW, Microval, Saint-Just-Malmont, France
2D PPNT, Microval, Saint-Just-Malmont, France
Basic mesh, Di.pro Medical Devices, Torino, Italy
Basic Evolution mesh, Di.pro Medical Devices, Torino, Italy
Bard mesh, Davol, Inc., Warwick, RI, USA
Bard Soft mesh, Davol, Inc., Warwick, RI, USA
Biomesh P1, Cousin Biotech, Wervicq-Sud, France
Bulev B, Di.pro Medical Devices, Torino, Italy
Bulev UL, Di.pro Medical Devices, Torino, Italy
DynaMesh PP-Standard, FEG Textiltechnik mbH, Aachen, Germany
DynaMesh PP- Light, FEG Textiltechnik mbH, Aachen, Germany
EasyProthes, TransEasy Medical Tech. Co. Ltd, Beijing, China
Hertra 0, HerniaMesh, S.R.L., Torino, Italy
Hermesh 3,4,5,6,7,8, HerniaMesh, S.R.L., Torino, Italy
Lapartex, Di.pro Medical Devices, Torino, Italy
Optilene, B. Braun Melsungen AG, Melsungen, Germany
Optilene LP, B. Braun Melsungen AG, Melsungen, Germany
Optilene Mesh Elastic, B. Braun Melsungen AG, Melsungen, Germany
Parietene Flat Sheet, Medtronic, Minneapolis, MN, USA
Parietene Lightweight, Medtronic, Minneapolis, MN, USA
Premilene, B. Braun Melsungen AG, Melsungen, Germany
Premium, Cousin Biotech, Wervicq-Sud, France
Prolene, Ethicon Inc., Somerville, NJ, USA
Prolene Soft Mesh, Ethicon Inc., Somerville, NJ, USA
ProLite, Getinge Group, Wayne, NJ, USA
Repol Angimesh 0,1,8,9, Angiologica, S. Martino Sicc., Italy
SMX, THT Bio-Science, Montpelier, France
SMH2, THT Bio-Science, Montpelier, France
SMH, THT Bio-Science, Montpelier, France
Surgimesh WN, Aspide Medical, St. Etienne, France
Surgipro Monofilamented, Covidien plc, Dublin, Ireland
Surgipro Multifilamented, Covidien plc, Dublin, Ireland
Surgipro Open Weave, Covidien plc, Dublin, Ireland
TiMESH, GfE Medizintechnik, Nuremburg, Germany
TiLENE, GfE Medizintechnik, Nuremburg, Germany
TiLENE Blue, GfE Medizintechnik, Nuremburg, Germany
VitaMesh—Getinge Group, Wayne, NJ
VitaMesh Blue—Getinge Group, Wayne, NJ

especially for the Trabucco "sutureless" repair. The *Hermesh 3–8* have a huge variety of weights and sizes and can be used in either open or laparoscopic repairs (Fig. 7.55). The graduated weights of these vary from the heaviest (3) to the lightest (8). *Lapartex* is a heavier product than some of the other materials (Fig. 7.56). This product was discontinued during the producton of this textbook and is no longer available.

Optilene products are all lightweight materials that vary from the heaviest by that name (60 g/m^2) to the *Elastic* (48 g/m^2) and the lighter *LP* (36 g/m^2). The Elastic version has unequal pore sizes (3.6 × 2.8 mm) to allow for multidirec-

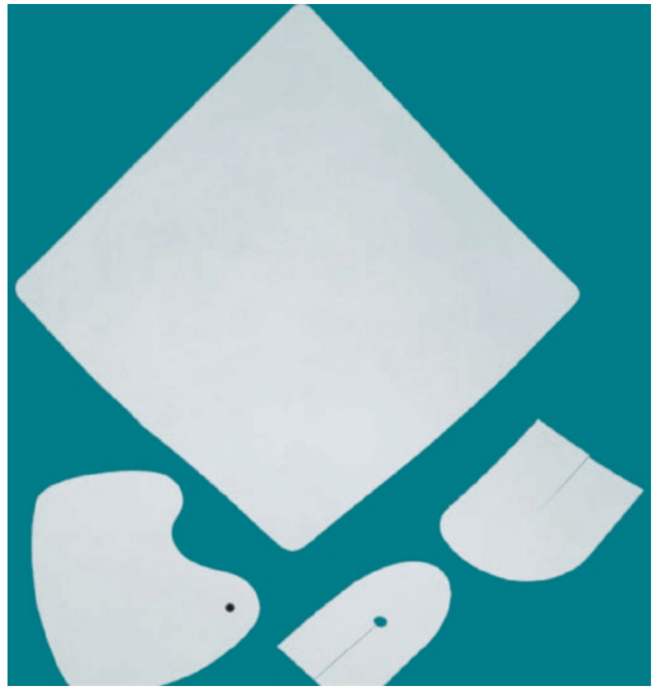

Fig. 7.39 2D PPNT

Fig. 7.40 Basic

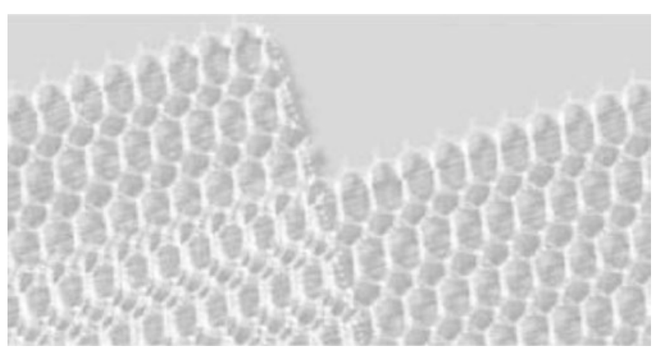

Fig. 7.41 Basic evolution

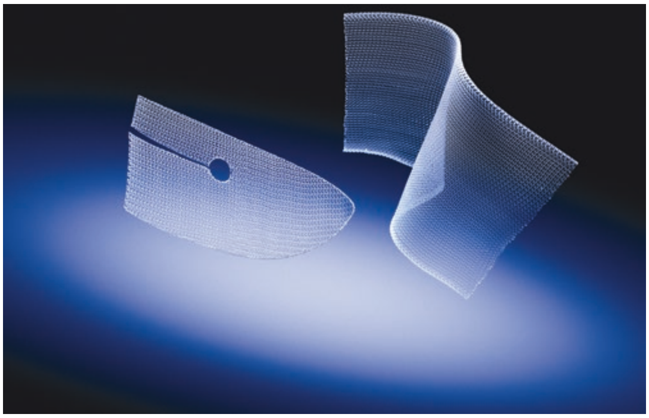

Fig. 7.42 Bard mesh (flat and preshaped)

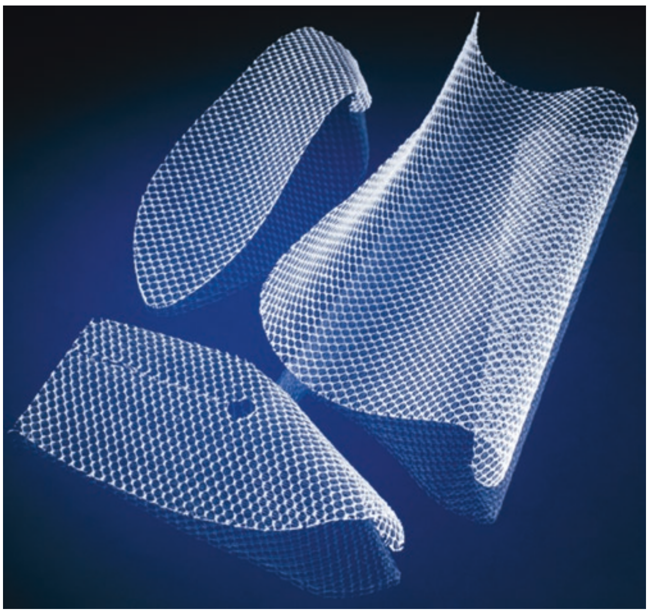

Fig. 7.43 Bard soft mesh (flat and preshaped)

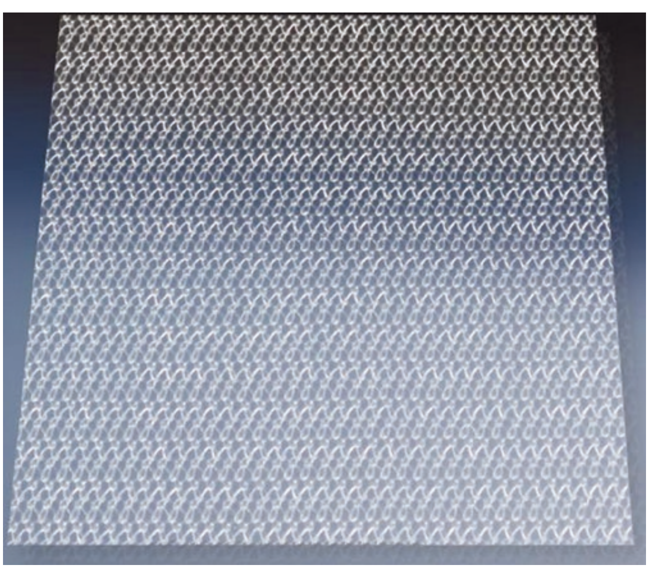

Fig. 7.44 Biomesh P1

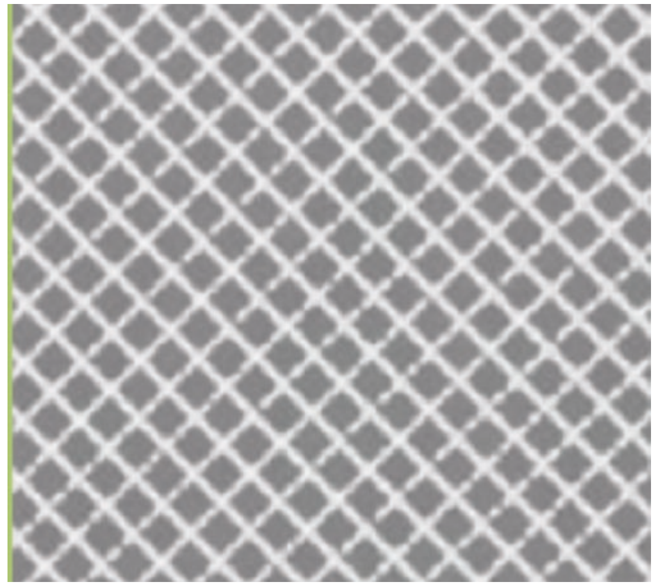

Fig. 7.45 Premium

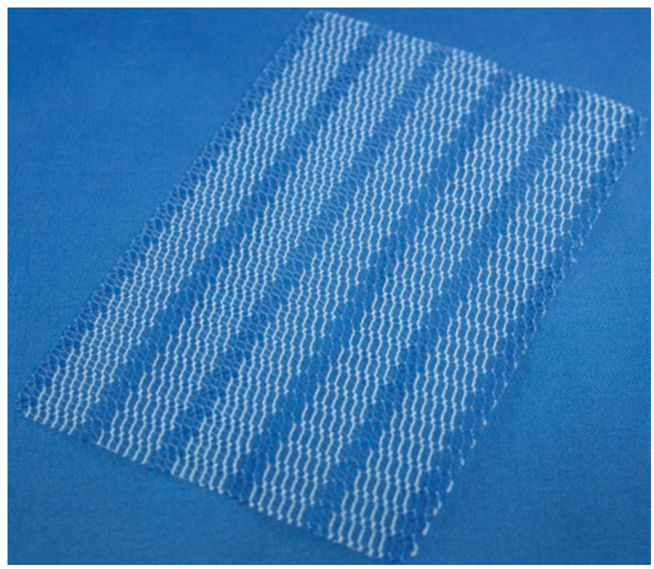

Fig. 7.46 Bulev

Fig. 7.47 Bulev UL

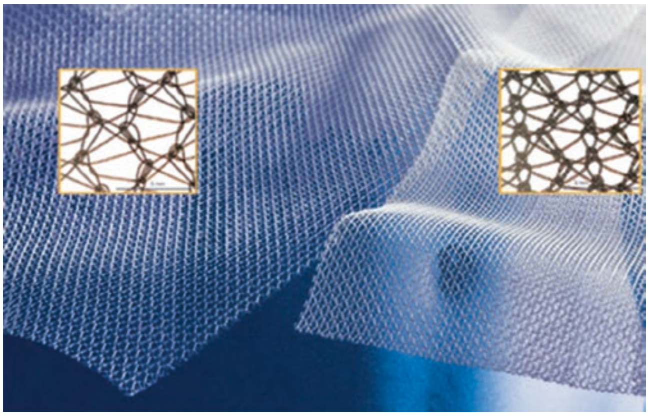

Fig. 7.48 Dynamesh (light and standard)

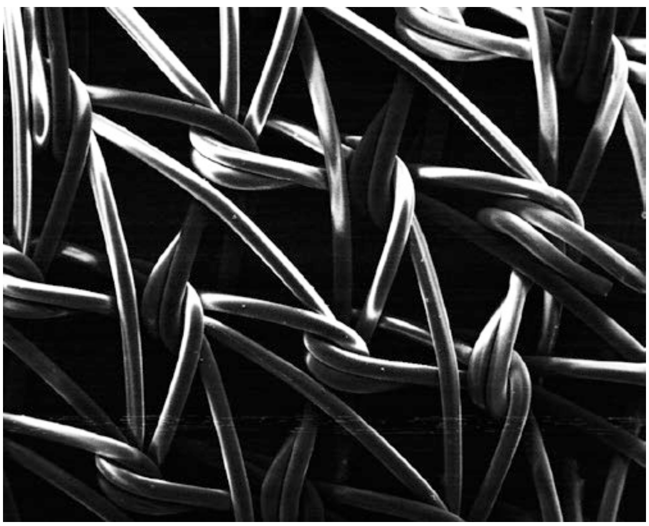

Fig. 7.49 Easy prothes (heavy weight)

Fig. 7.50 Easy prothes 70

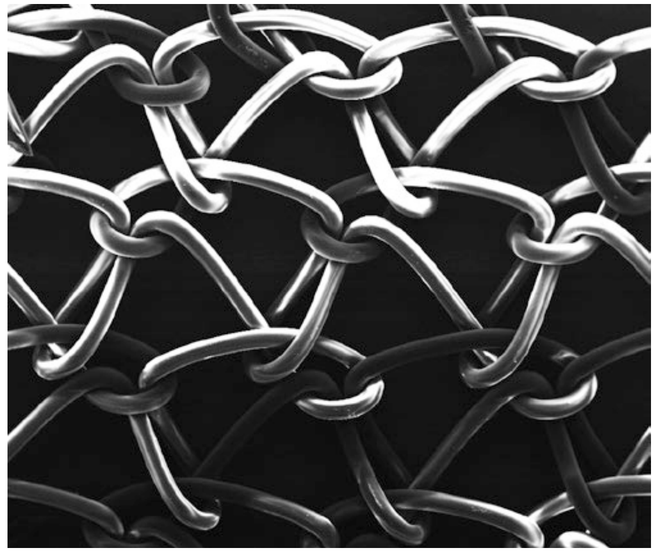

Fig. 7.51 Easy prothes 60

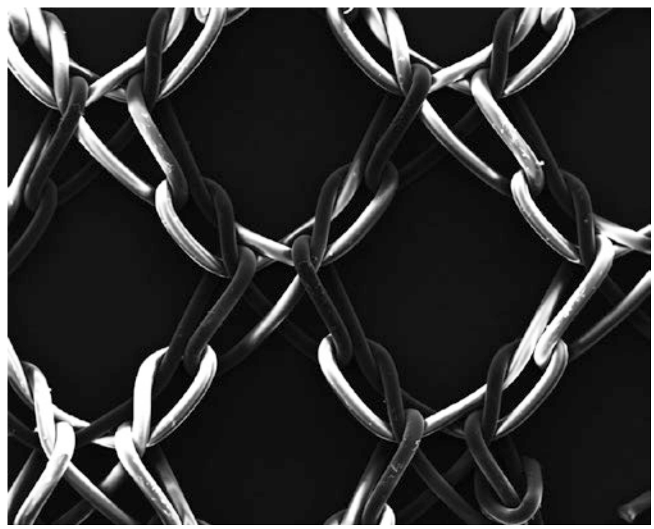

Fig. 7.52 Easy prothes (light weight)

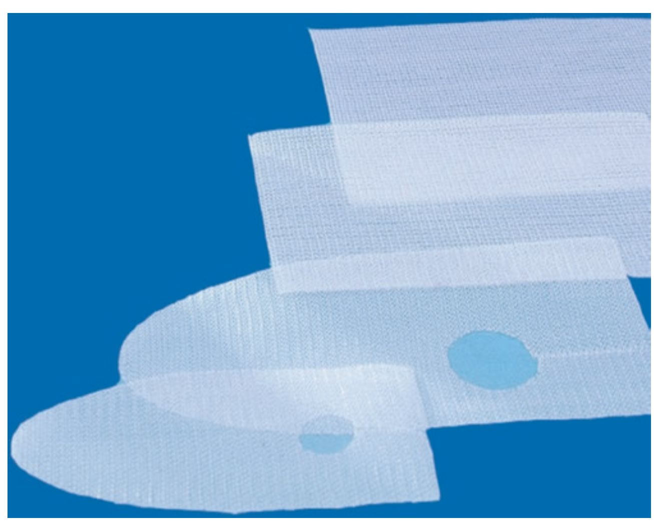

Fig. 7.53 Easy prothes 60

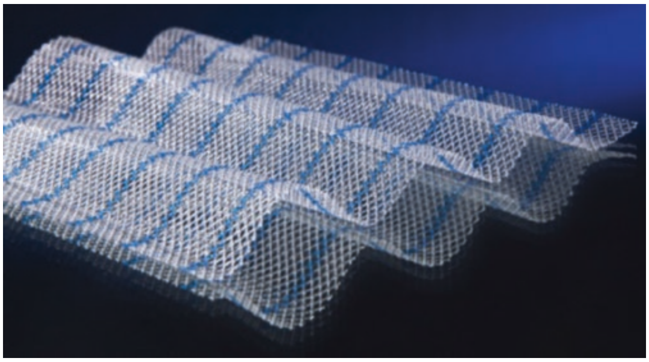

Fig. 7.54 Easy prothes (light weight)

Fig. 7.55 Hermesh

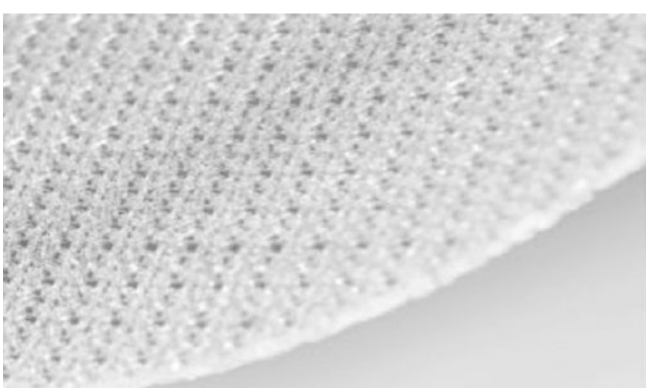

Fig. 7.56 Lapartex (this product is no longer produced)

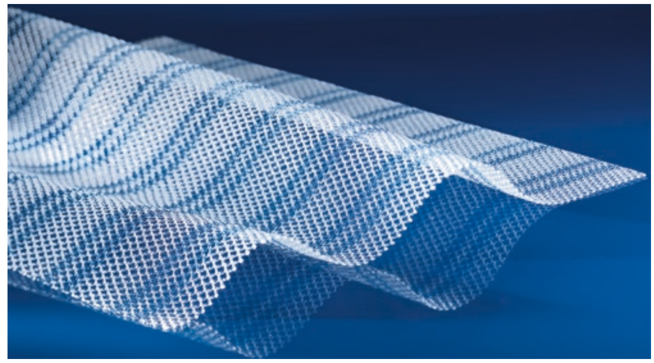

Fig. 7.57 Optilene

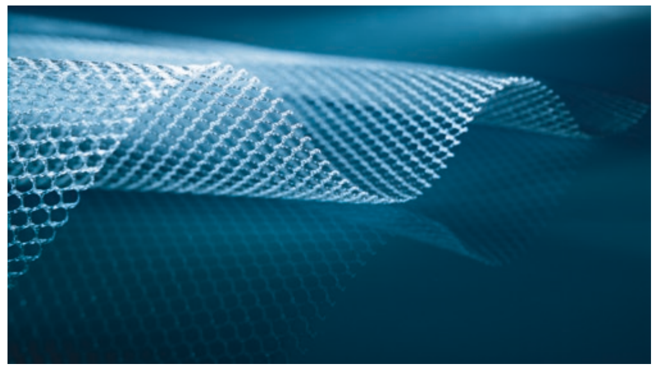

Fig. 7.58 Optilene elastic

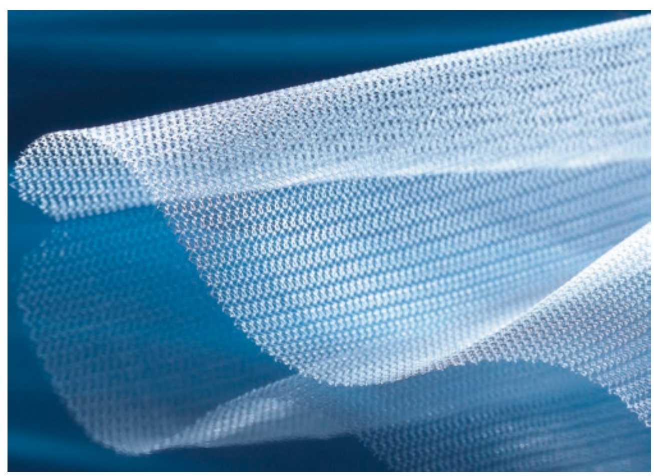

Fig. 7.59 Optilene LP

tional elasticity (Figs. 7.57, 7.58, and 7.59). Unlike some of the other prostheses, the blue lines in the Optilene do not signify an absorbable component. *Parietene Flat Sheet and Parietene Lightweight* products are monofilament flat sheet products (Fig. 7.60). *Premilene* is the heaviest weight (82 g/m^2) product in the Braun flat mesh product line (Fig. 7.61).

Premium mesh is a lightweight product similar to the Biomesh P1 described above (Fig. 7.44). This is configured into various sizes and shapes for use in open or laparoscopic inguinal and extraperitoneal ventral hernia repair (Fig. 7.62). *Prolene* is also a heavier weight mesh material and it is one of the older products available (Fig. 7.63). *Prolene Soft Mesh* is the lighter weight version that has larger pores than the original mesh and blue lines to help differentiate it (Fig. 7.64). *ProLite* was one of the earliest meshes that were introduced as a lighter weight material (Fig. 7.65). Today, it is considered a mid-weight mesh. *ProLite Ultra* possesses even less weight of mesh than ProLite (Fig. 7.66).

Repol Angimesh 0, 1, 8, 9 are all similar and differentiated in the weights and weaves from each other. The 0 is the lightest and 9 is the heaviest. *SurgiMesh WN* is a non-woven microfiber PP product that is extremely lightweight and has a differing microstructure than the other materials listed in this section (Fig. 7.67). It is available in several configurations for open or laparoscopic procedures but cannot be placed against the viscera. *Surgipro* was originally introduced as a multifilament mesh (Fig. 7.68). Because of the demand for a monofilament product, the second-generation product was released (Fig. 7.69). The multifilament material is noticeably softer than the monofilament one. There is now an open weave product called the *Surgipro Open Weave* (Fig. 7.70). *SMX* is a heavy product designed for all hernia repairs, either open or laparoscopic (Fig. 7.71). It is part of the "Swing-mesh" product line. It is available in a lightweight and ultra light material as *SMH2* and *SMH,* respectively (Fig. 7.72).

TiMESH is similar to the lightweight materials and has a bonded layer of titanium on the fibers of the PP using nanotechnology (Figs. 7.73 and 7.74). This is supposed to allow ingrowth in a flexible manner while inhibiting the develop-

Fig. 7.60 Parietene flat sheet (All rights reserved. Used with Permission of Medtronic)

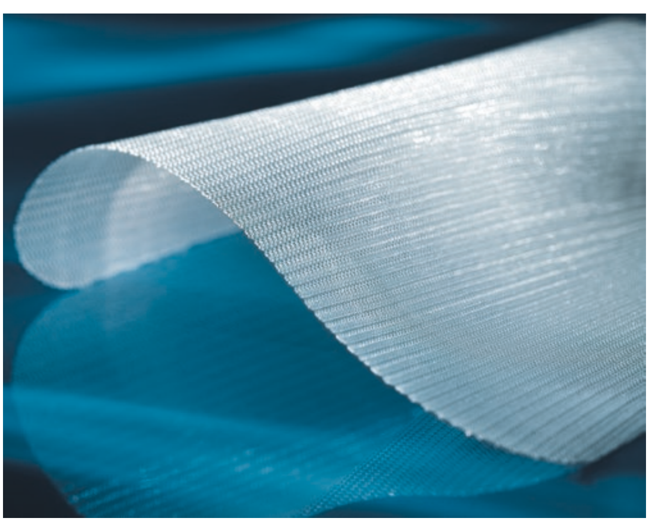

Fig. 7.61 Premilene

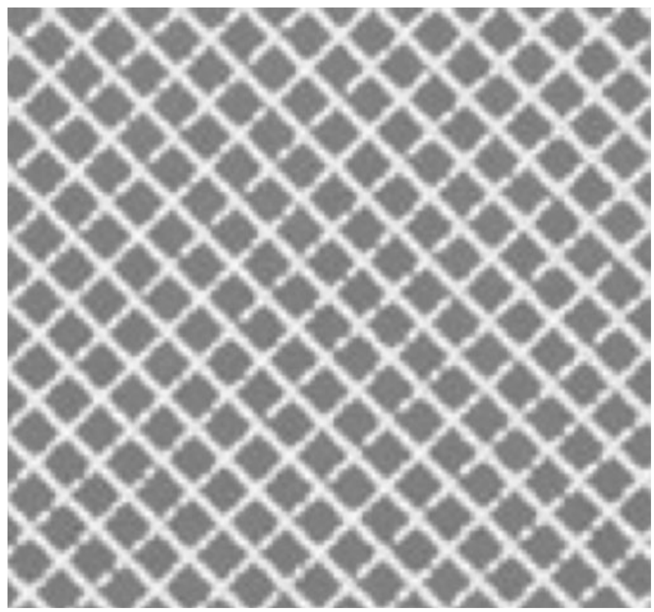

Fig. 7.62 Premium

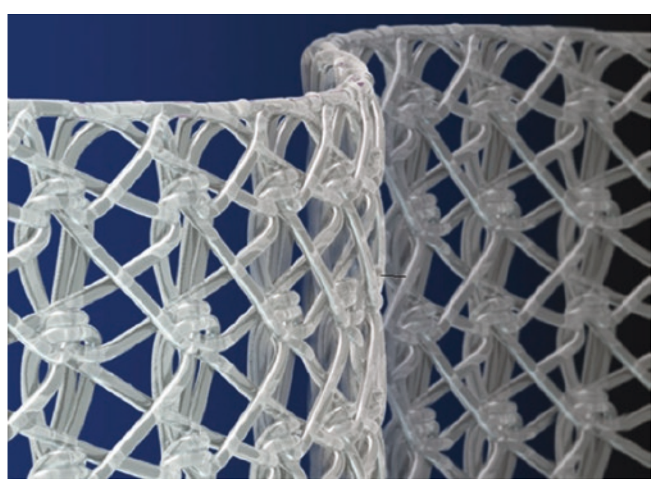

Fig. 7.63 Prolene (Image courtesy of Ethicon, Inc.)

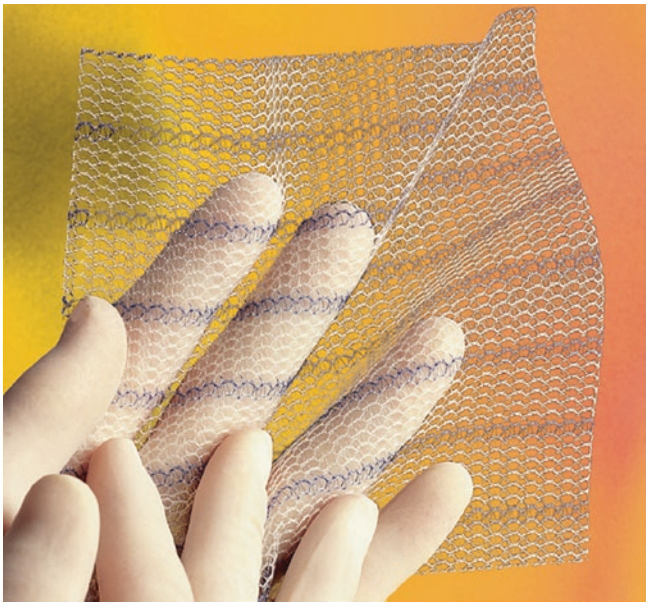

Fig. 7.64 Prolene soft mesh (Image courtesy of Ethicon, Inc.)

Fig. 7.66 ProLite ultra

Fig. 7.65 ProLite

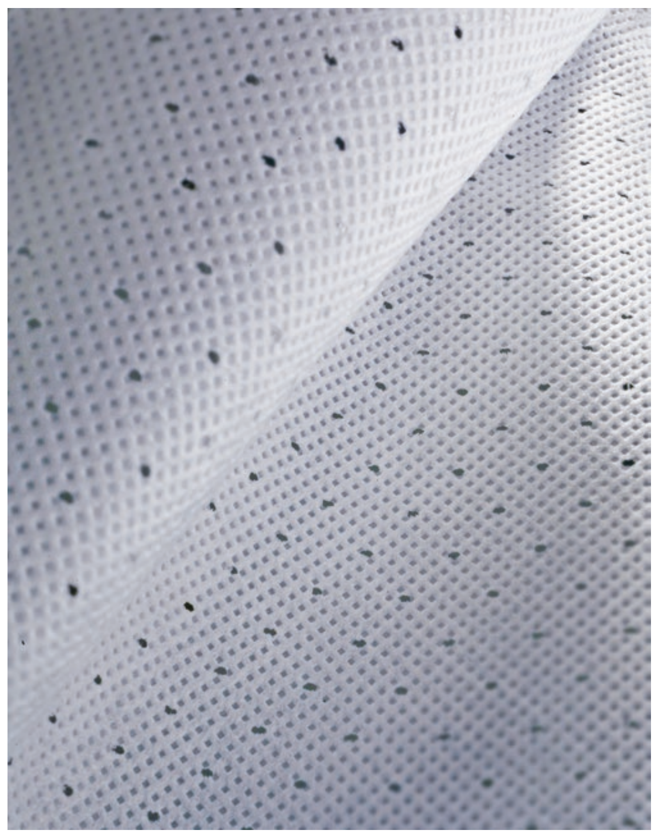

Fig. 7.67 SurgiMesh WN

ment of a scar plate. It can be used in either the intraperitoneal or extraperitoneal positions. *TiLENE Blue* has blue lines incorporated into the material to aid in positioning and can also be used in the intra- or extra-peritoneal planes (Fig. 7.75). It is also available without the blue lines as *TiLENE*. *VitaMesh* is of a single macroporous material (50 g/m^2) available for open and laparoscopic repair (Fig. 7.76). *VitaMesh Blue* is the lighter weight version (28 g/m^2) of this flat mesh and is differentiated by its blue color (Fig. 7.77). These products are singular in that they are made of condensed PP rather than the traditional PP. Regular PP mesh becomes condensed PP mesh

Fig. 7.68 Surgipro multifilament ()

Fig. 7.69 Surgipro monofilament ()

through compression during a post-knit heat treatment. This condensing process serves to reduce mesh thickness approximately 70%. This is said to improve deliverability through increased smoothness because fiber crossover points are flattened. Improved recovery of the shape of the mesh is asserted because the knots in the mesh are flattened. This provides greater shape memory than their non-flattened PP.

The differences in the appearance of the prosthetics are easily seen in these photos. The size of the pores of these materials as well as the thickness of the product will have a significant impact on the stiffness. These factors affect the degree of scarring within the tissues. Additionally, the pore sizes vary greatly from each of these products. Since the last edition of this textbook, the lighter weight products have significantly impacted the prosthetic repair of hernias. The current thought is that, for the most part, there is less pain and less scar plate with these lightweight, larger pore meshes. In some cases, these may have become "too thin" and there are reports of mesh fracture and hernia recurrence. Generally, these are well accepted in the inguinal area but one should be sure of the strength of these products in the ventral and incisional hernia repair.

Like the polypropylene materials, the polyester flat sheets can be used in inguinal and ventral hernia repair and can be placed either via an open approach or a laparoscopic technique (Table 7.12). The preponderance of the polyester products that are currently available is produced in various configurations and most have some type of coating. These are listed elsewhere in this chapter.

2D PET, Angimesh R2, R2–1, R2–9 and *Biomesh A2* are all fairly similar in appearance. The *2D PET* and *Biomesh A2*, however, have been configured into various shapes and sizes to allow use in open or laparoscopic inguinal and open ventral hernia repair (Figs. 7.78 and 7.79). *Angimesh R2* is multifilament polyester (Fig. 7.80). *Angimesh R2–1* and *R2–9* are monofilament materials very similar in appearance and differ only in thicknesses, *R2–1* being thinner than *R2–9* (Figs. 7.81 and 7.82). *CO3+* is a rather unique material and is actually combination products that are configured in a variety of shapes and sizes. As such, it will be mentioned later in the chapter again. It is a three-dimensional weave of polyester that has impregnated polyurethane. The differentiating factor are the knitted "grips" that are on both sides of the product (Fig. 7.83). These are designed to fixate the mesh. It can be used in open or laparoscopic surgery and for nearly all hernias.

Fig. 7.70 Surgipro open weave (All rights reserved. Used with Permission of Medtronic)

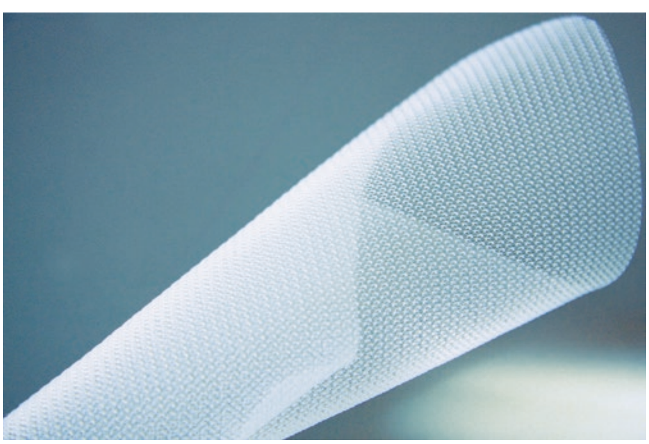

Fig. 7.71 SMX

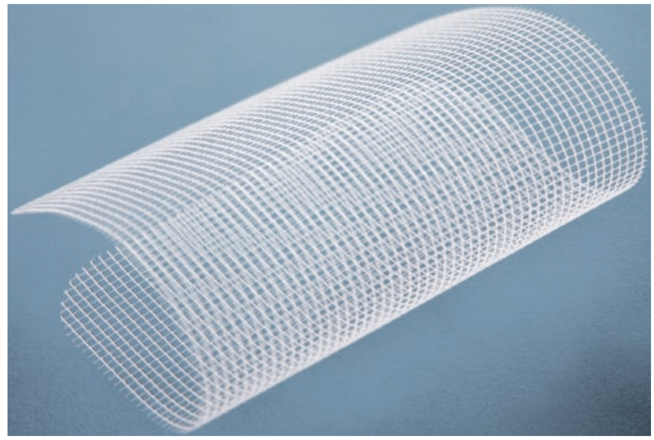

Fig. 7.72 SMH2

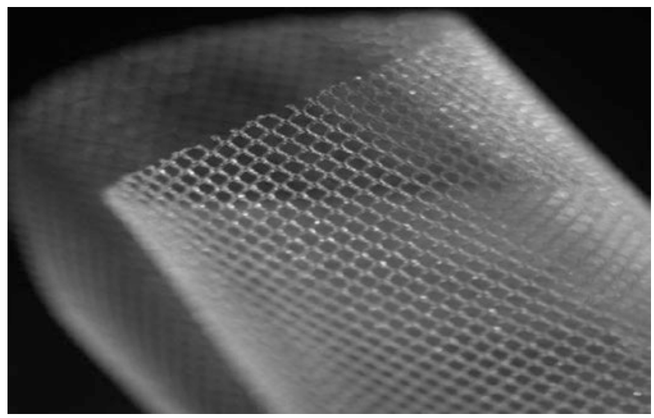

Fig. 7.73 TiMESH

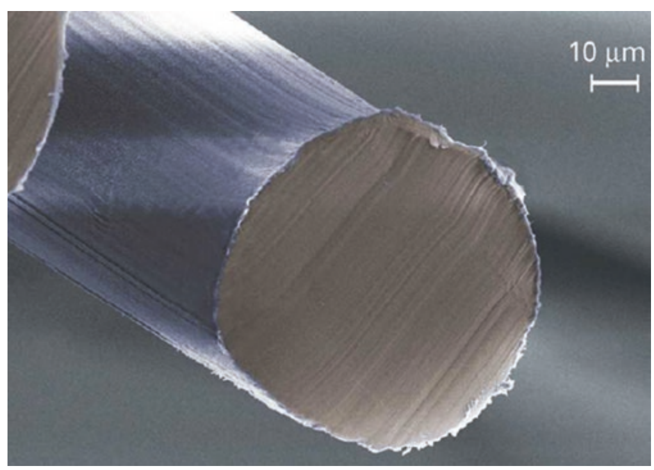

Fig. 7.74 TiMESH (SEM)

The *Parietex Flat Sheet Mesh* is available in two- or three-dimensional weaves (Fig. 7.84). The 2D material is more rigid and is touted for laparoscopic repairs due to this fact. The 3D product is more supple and soft. *Parietex Lightweight* product is a monofilament product (Fig. 7.85). *Parietex Monofilament Macroporous* is available in a flat sheet and is a two-dimensional construct (Fig. 7.86). *SM2* is a heavy-weight bi-dimensional weave material that is indicated for all hernia repairs (Fig. 7.87).

SM3 and *SM3+* are three-dimensional weaves of polyester (Figs. 7.88 and 7.89). Both are available in a variety of shapes and sizes and can be used in open or laparoscopic

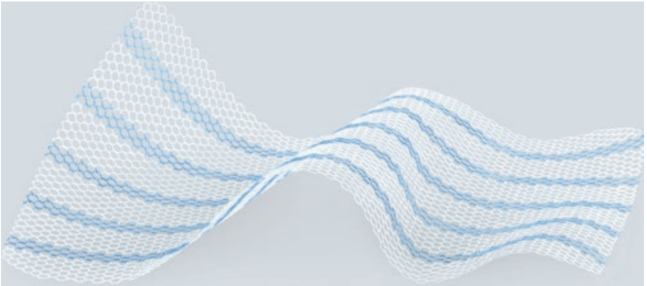

Fig. 7.75 TiLENE blue

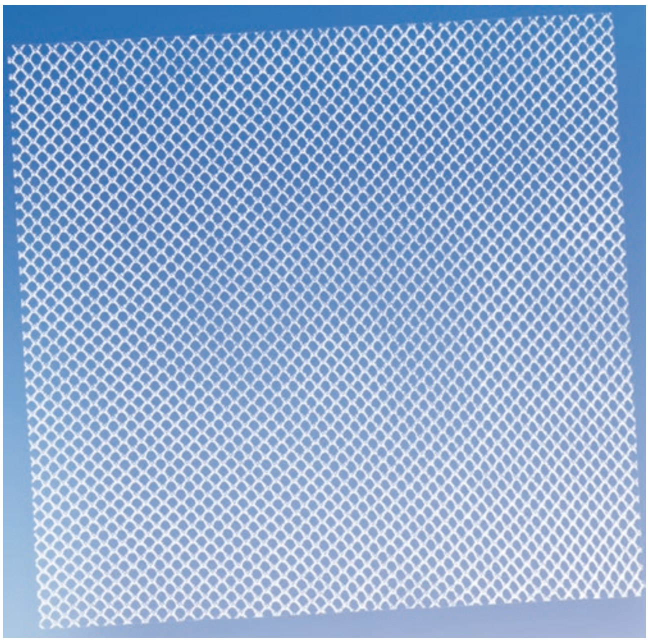

Fig. 7.76 Vitamesh

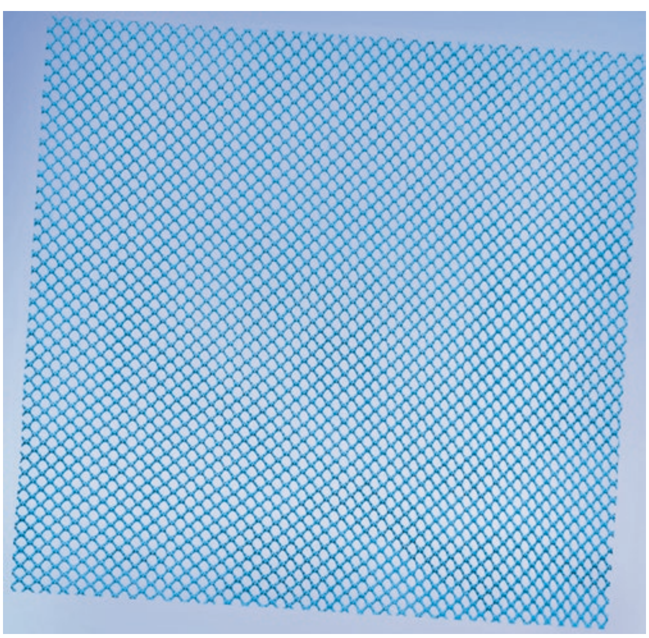

Fig. 7.77 Vitamesh blue

Table 7.12 Flat polyester products

2D PET, Microval, Saint-Just-Malmont, France
Angimesh R2, Angiologica, S. Martino Sicc., Italy
Angimesh R2-1, Angiologica, S. Martino Sicc., Italy
Angimesh R2-9, Angiologica, S. Martino Sicc., Italy
Biomesh A2, Cousin Biotech, Wervicq-Sud, France
CO3+, THT Bio-Science, Montpelier, France
Parietex Flat Sheet Mesh, Medtronic, Minneapolis, MN, USA
Parietex Lightweight Mesh, Medtronic, Minneapolis, MN, USA
Parietex Monofilament Macroporous Mesh, Medtronic, Minneapolis, MN, USA
SM2, THT Bio-Science, Montpelier, France
SM3, THT Bio-Science, Montpelier, France
SM3+, THT Bio-Science, Montpelier, France
Versatex, Medtronic, Minneapolis, MN, USA

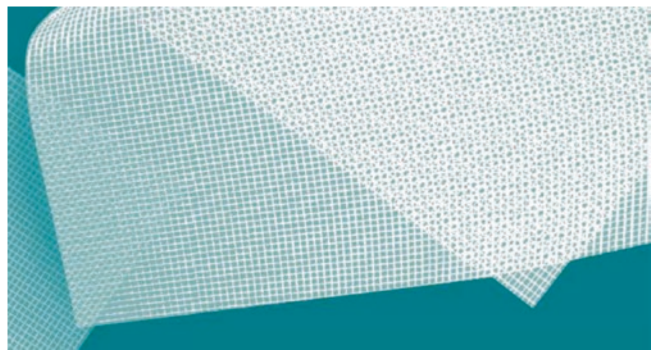

Fig. 7.78 2D PET

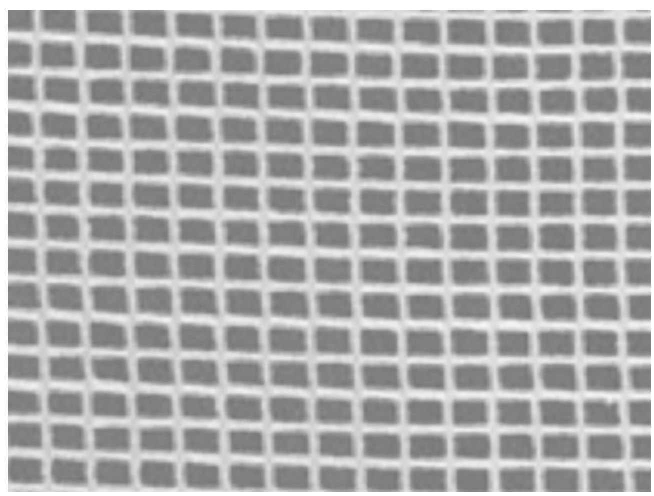

Fig. 7.79 Biomesh A2

applications. *SM3* is pure polyester while the *SM3+* is polyester with impregnated polyurethane and is configured in anatomical shapes. *Versatex* has a 3D construct and is macroporous (Fig. 7.90). It is a medium weight (64 g/m^2) monofilament product that is designed for placement in the

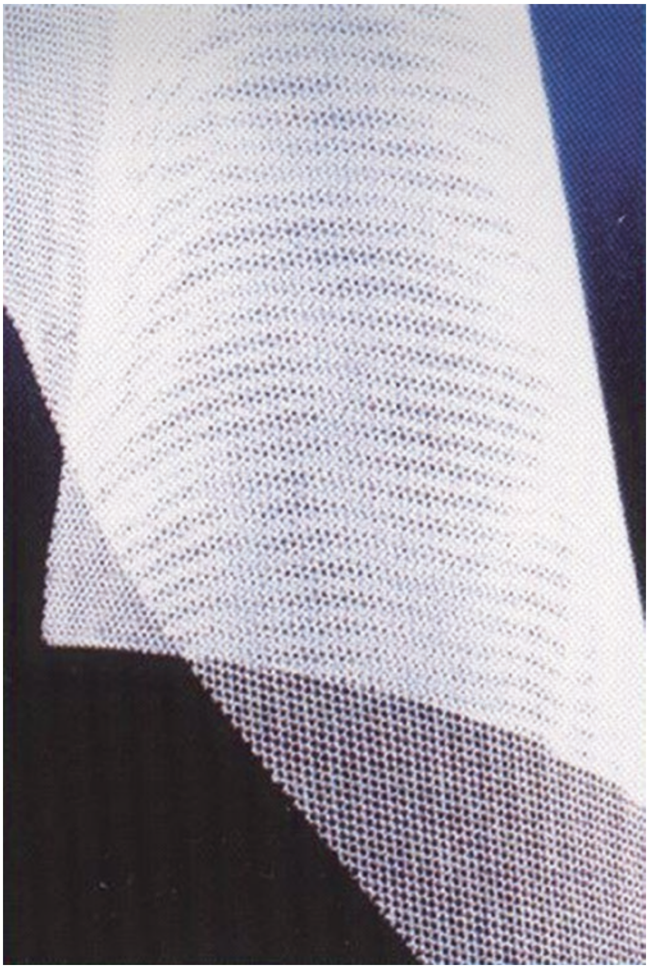

Fig. 7.80 Angimesh R2

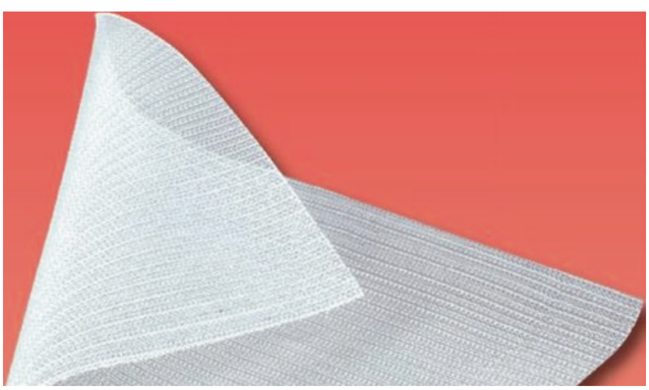

Fig. 7.81 Angimesh R2-1

preperitoneal space. It also has a central teardrop that is two-dimensional polyester and is placed as an orientation aid.

Expanded polytetrafluoroethylene (ePTFE) prostheses (Table 7.13) have also been available in a flat sheet configuration for many years. In fact, the earliest products used in the intraperitoneal space for incisional hernia repair were of

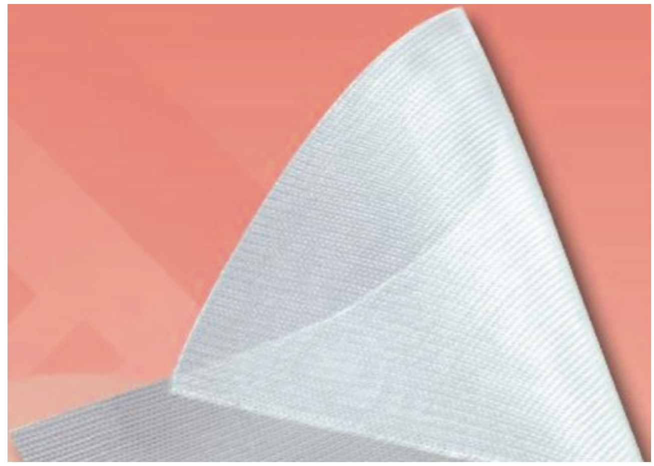

Fig. 7.82 Angimesh R2-9

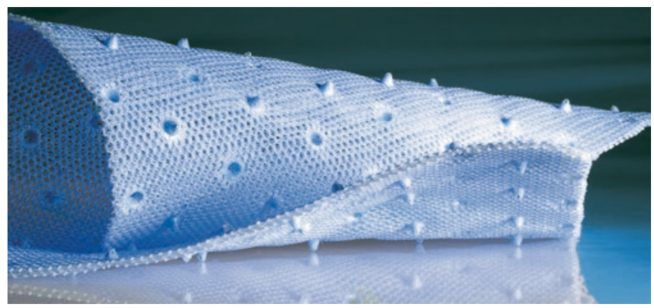

Fig. 7.83 CO3+

Fig. 7.84 Parietex flat sheet (All rights reserved. Used with Permission of Medtronic)

ePTFE. Because of their structure, they are solid and white unless an antimicrobial agent has been added.

The current DualMesh products are very similar in construction and are one of the oldest "tissue-separating" products (Fig. 7.91). These represent the second generation of this prosthetic material. These all have two distinctly different surfaces. One side is very smooth and has interstices of 3 μm while the other has the appearance of corduroy with an approximate "ridge to ridge" distance of 1500 μm. This prosthesis is designed for use in the intraperitoneal space. The smooth side must therefore be placed facing the viscera as this minimizes the potential for adhesion formation. The rough surface is applied to the abdominal wall so that maximum parietal tissue

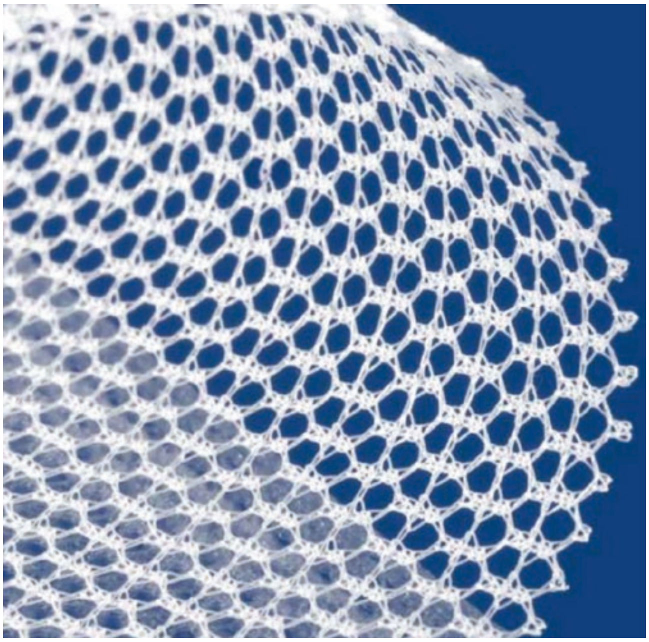

Fig. 7.85 Parietex lightweight

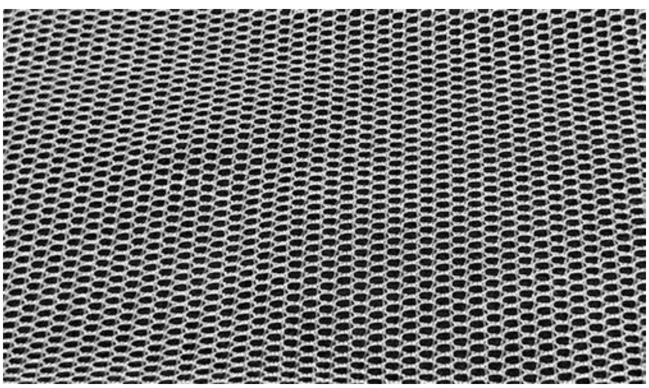

Fig. 7.86 Parietex monofilament macroporous

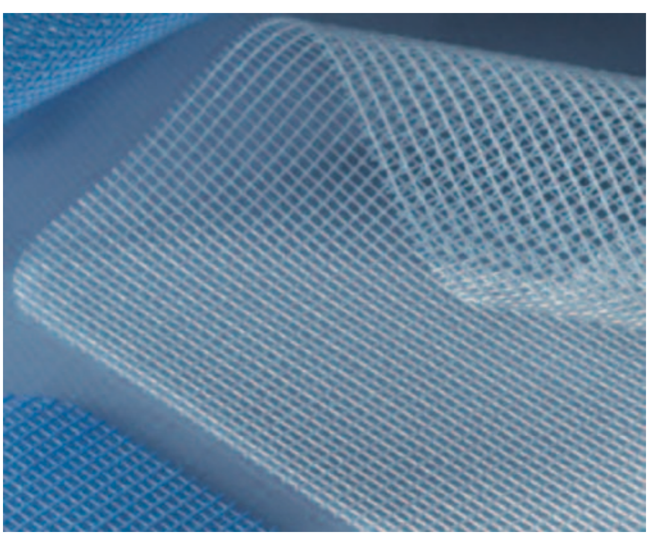

Fig. 7.87 SM2

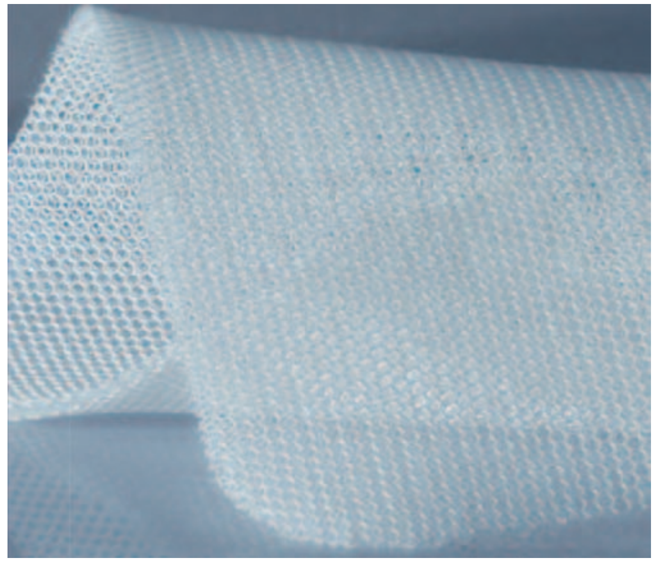

Fig. 7.88 SM3

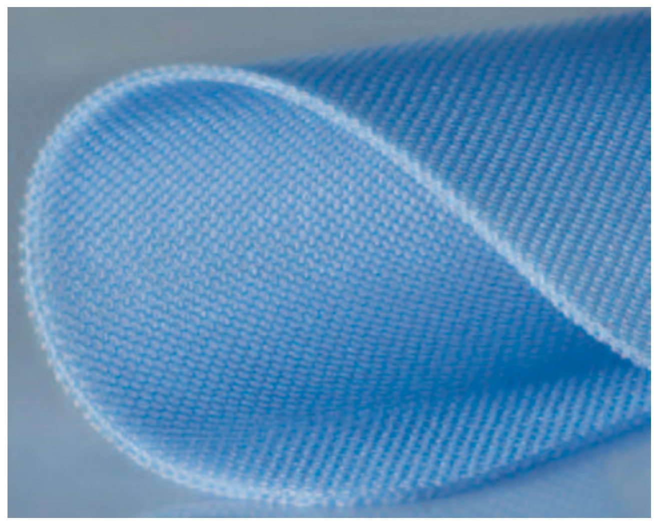

Fig. 7.89 SM3+

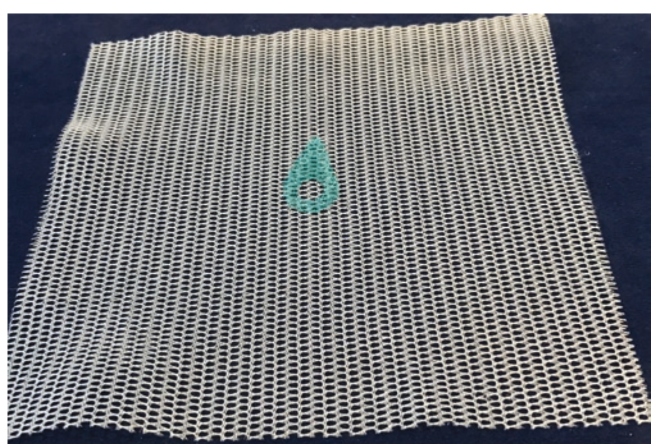

Fig. 7.90 Versatex

penetration will occur. *DualMesh* is available in one thickness, 1 mm. It is available with the impregnation of silver and chlorhexidine as *DualMesh PLUS* (Fig. 7.92). The two-millimeter product is only available as DualMesh Plus with the antimicrobial agents within it. These two chemicals are antimicrobial agents that are added to decrease the risk of infection and, because of the silver, impart a brown color to the "PLUS" products. At this time, these products are the only synthetic materials impregnated with any type of any antimicrobial or bactericidal agents. *DualMesh PLUS with Holes* (Fig. 7.93) is of the same construction as that of the DualMesh. The penetration of the holes requires that this product be of 1.5 mm in thickness. The concept of the addition of these perforations is that there may be greater penetration of the fibroblasts and other cells across the material. Additionally, seroma formation might be diminished.

Dulex is manufactured of laminated ePTFE and is available in 1 or 2 mm thick (Fig. 7.94). One surface of the material is studded with numerous outcroppings as seen on the scanning electron microscopic view that are approximately 400 µm apart. This gives the product the gross appearance of sandpaper. The intent of this surface is to provide for greater fibroblastic attachment and subsequent greater collagen deposition on this parietal surface. When used in the intraperitoneal fashion, the smooth surface should contact the intestine.

MycroMesh is also a dual-sided perforated prosthetic with one surface of 3 µm and the other of 17–22 µm (Fig. 7.95). The latter surface is textured. This material is perforated for reasons that are similar to that of the DualMesh Plus with holes. It is only 1 mm thick, however. *Mycromesh PLUS* is impregnated with the antimicrobials silver and chlorhexidine (Fig. 7.96). It is not designed for intraperitoneal usage.

Table 7.13 ePTFE products

DualMesh, W. L. Gore & Associates, Elkhart, DE, USA
DualMesh Plus, W. L. Gore &Associates, Elkhart, DE, USA
DualMesh Plus with Holes, W. L. Gore &Associates, Elkhart, DE, USA
Dulex, Davol, Inc., Warwick, RI, USA
MycroMesh, W. L. Gore &Associates, Elkhart, DE, USA
MycroMesh Plus, W. L. Gore &Associates, Elkhart, DE, USA
Soft Tissue Patch, W. L. Gore &Associates, Elkhart, DE, USA

Fig. 7.91 DualMesh

Fig. 7.92 DualMesh PLUS

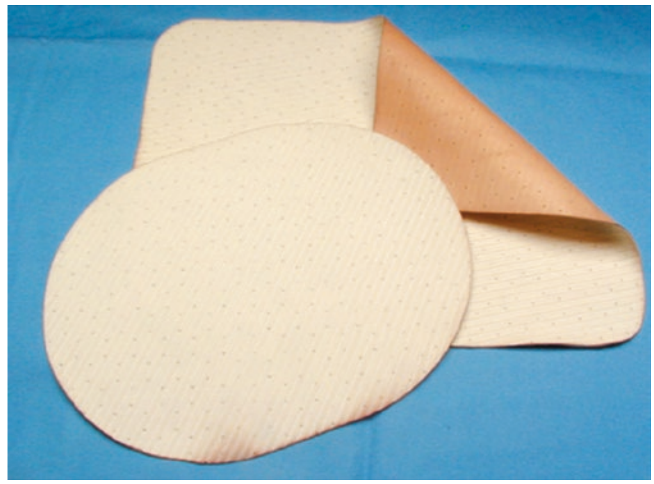

Fig. 7.93 DualMesh PLUS with holes

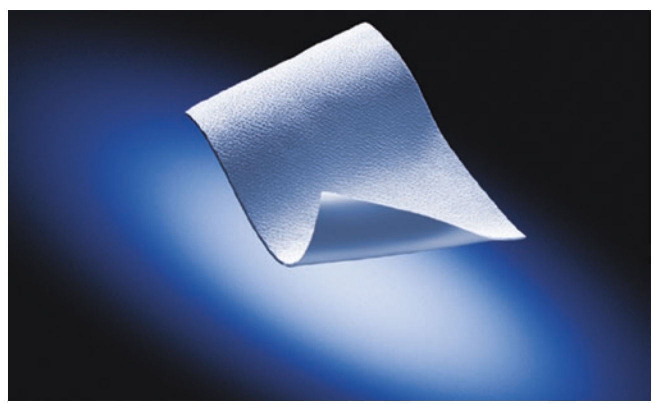

Fig. 7.94 Dulex

Fig. 7.95 MycroMesh

Soft Tissue Patch is the earliest implants of these ePTFE products and was the product utilized in the very first laparoscopic incisional hernia repair (Fig. 7.97). The variety of available configurations of this product has increased over the last several years. Its use, however, has waned because of the development of the other products that are listed in Table 7.12. Like the *MycroMesh*, it should not contact any viscera when applied.

Miscellaneous Flat Products

There are ranges of materials that do not fit into the exact categories above (Table 7.14). For instance, *Inomesh* is a product made of PVDF with laser cut holes (Fig. 7.98). *MotifMesh* and *Omyra* are identical in design and concept (Figs. 7.99 and 7.100). These are made of condensed PTFE (cPTFE) and designed for use in contact with the intestine. The PTFE is laminated and then condensed with a heated compression process. The nonporous material is then laser micromachined to

Fig. 7.96 MycroMesh PLUS

Fig. 7.97 Soft tissue patch

Table 7.14 Miscellaneous flat mesh products

Inomesh, Secqure/Medlinx Acacia, Singapore
Mosquito netting, numerous manufacturers
MotifMESH, Proxy Biomedical Ltd, Galway, Ireland
Omyra, B. Braun Melsungen AG, Melsungen, Germany
Rebound HRD V, ARB Medical, Minneapolis, MN, USA
TiO_2 Mesh, BioCer GmbH, Bayreuth, Germany

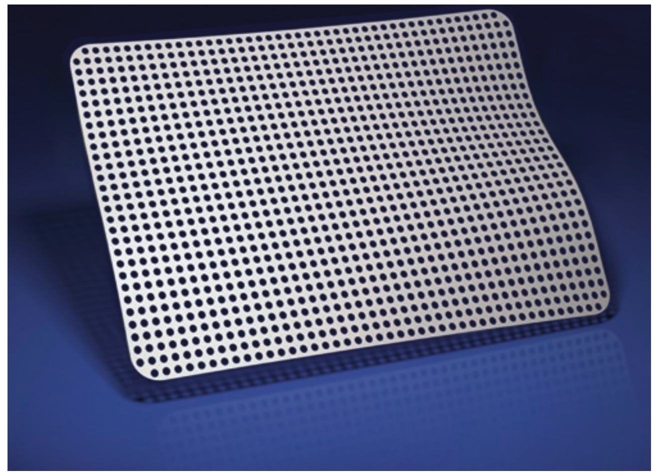

Fig. 7.98 Inomesh

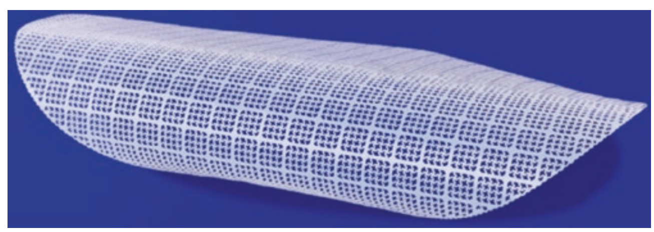

Fig. 7.99 MofifMesh

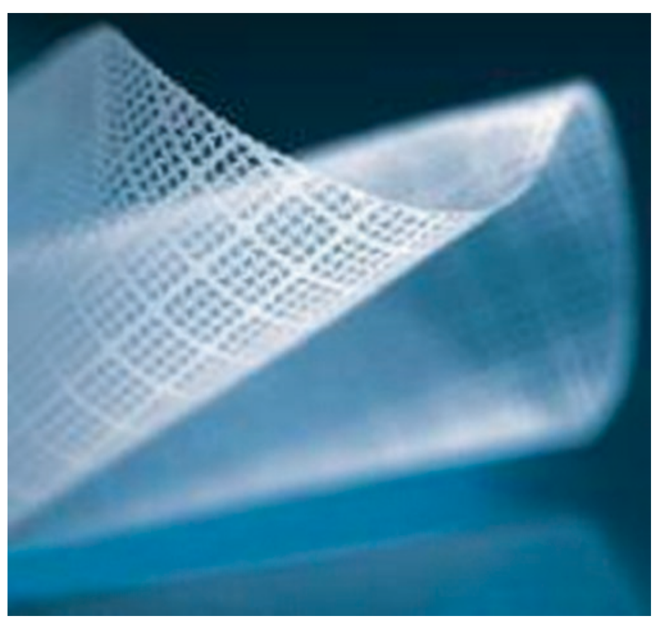

Fig. 7.100 Omyra

create the macroporous structure of the final product. They claim to be “a bacterial resistant anti-adhesive mesh.”

Rebound HRD V is a unique material in that it is PP that has a ring of nitinol to stiffen the product and is available as an oval shape for umbilical hernia repair (Fig. 7.101). *TiO_2 Mesh* is a titanized PP is that is completely covered by a 100% pure titanium oxide layer (Fig. 7.102). It is lightweight (47 g/m^2), large pore (2.8 mm) and has blue orientation strips. It is stated to be hydrophilic so that there is an apparent “stickiness” to the product, which eases intraoperative handling. It can be used in either open or laparoscopic inguinal and incisional hernia repairs.

This chapter would be remiss if it did not include the use of mosquito netting for the repair of inguinal hernias. This has been reported in the past in underserved countries. It appears that if this material is acceptable for use in areas of the world where the other products described in this chapter are either unavailable or are too expensive [11, 12].

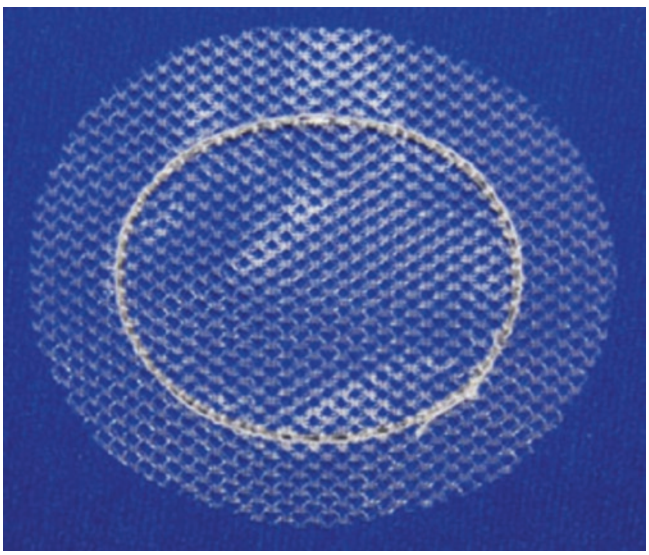

Fig. 7.101 Rebound HRD V

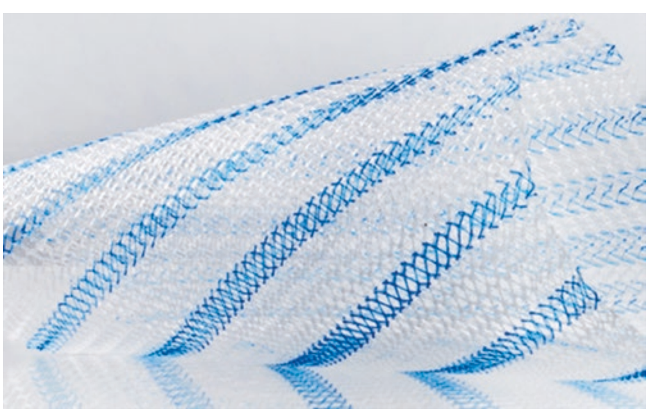

Fig. 7.102 TiO_2

Flat Mesh Devices for Inguinal Hernioplasty

There are several modifications of the shape of the synthetic meshes described above. For the most part, the ones listed in Table 7.15 are merely the same permanent material (Table 7.11) that is either pre-shaped with rounded edges and/or have a slit and/or keyhole to be used for open inguinal hernia repair. Some of these keyholes will be located on the long axis of the mesh to be placed while others will be placed on the short axis of the mesh. If there is a significant modification, it is noted below.

Angimesh XCO is a combination of two layers of PP (Fig. 7.103). One folds over the other to be used as a sutureless inguinal hernia repair, if desired it is available in the thick (*A5*)

Table 7.15 Flat mesh devices

2D PPT Std, Microval, Saint-Just-Malmont, France
2D PPT LW, Microval, Saint-Just-Malmont, France
2D PPNT, Microval, Saint-Just-Malmont, France
2D PET, Microval, Saint-Just-Malmont, France
Angimesh XCO A5, Angiologica, S. Martino Sicc., Italy
Angimesh XCO A9, Angiologica, S. Martino Sicc., Italy
Bard Mesh, Davol, Inc., Warwick, RI, USA
Bard Soft Mesh, Davol, Inc., Warwick, RI, USA
Biomesh A2, Cousin Biotech, Wervicq-Sud, France
CO3+, THT Bio-Science, Montpelier, France
C-Qur FX, Getinge Group, Wayne, NJ
Easy Prothes, TransEasy Medical Tech.Co.Ltd., Beijing, China
Hetra 1,2,2A, Herniamesh, Torino, Italy
Hertra 6, 6A, 7, Herniamesh, Torino, Italy
Hertra 9, 9A, Herniamesh, Torino, Italy
HydroCoat Mesh, Promethean Surgical Devices, East Hartford, CT, USA
MycroMesh, W. L. Gore & Associates, Elkhart, DE, USA
Optilene, Optilene LP mesh, B. Braun, Melsungen AG, Melsungen, Germany
Premiline mesh, B. Braun, Melsungen AG, Melsungen, Germany
Parietex ProGrip Polypropylene, Medtronic, Minneapolis, MN
Parietex ProGrip Polyester, Medtronic, Minneapolis, MN
P1, Cousin Biotech, Wervicq-Sud, France
P3, Di.pro Medical Devices, Torino, Italy
P3 Evolution, Di.pro Medical Devices, Torino, Italy
Premium, Cousin Biotech, Wervicq-Sud, France
ProLite, Getinge Group, Wayne, NJ
ProLite Ultra, Getinge Group, Wayne, NJ
SM2+, THT Bio-Science, Montpelier, France
SM3, THT Bio-Science, Montpelier, France
SM3+, THT Bio-Science, Montpelier, France
SurgiMesh WN, Aspide Medical, St. Etienne, France
T4 Pre-shaped Mesh, HerniaMesh, S.R.L., Torino, Italy
TiLENE, GfE Medizintechnik, Nuremburg, Germany
TiPATCH, GfE Medizintechnik GmbH, Nuremburg, Germany
Wings, Angiologica, S. Martino Sicc., Italy

or standard (*A9*). *CO3+* has a similar configuration and has included grips. It is described in the flat mesh section above (Fig. 7.83). *Parietex ProGrip Polyester* is composed of the three-dimensional POL of Parietex with polylactic acid micro-grips (see above) and is manufactured with a left and a right mesh (Fig. 7.104). It is elliptical in shape with a colored marker on the median edge of the prosthesis to indicate the location of the suture that is placed at the pubic tubercle for fixation. There is a self-gripping flap that is designed to overlap the slit that is precut into the biomaterial, which allows for the exit of the cord structures through the mesh. This flap is placed in the inferior position of the inguinal floor. The manufacturer recommends that the external oblique fascia be closed below the cord structures so that there is no direct contact with the polyester fabric. There is a *Parietex ProGrip Polypropylene* version that is identical but is made of PPM as its name implies.

Hertra 1 and *2* are indicated for male inguinal hernias but the *Hertra 2A* can be used for male or female hernias (Fig. 7.105). *Hertra 6 and 6A* are lightweight materials (Fig. 7.106). They are all indicated for male hernias but the 6A can also be used for hernias in the female patient. The *Hertra 7* is an ultra lightweight material (Fig. 7.106, lower). Hertra 9 and 9A are preshaped with the patented quadraxial weave (Fig. 7.107). Both are recommended for inguinal hernias in males and the latter is also recommended for female patients. The T4 plug is actually a rounded flat sheet of mesh that is to be placed in the preperitoneal space (Fig. 7.108).

The *P3* is manufactured in light, medium, and heavy weight PPM with products for the male and female patient (Fig. 7.109). The "male" product is supplied with a slit and keyhole for the cord structures to pass while the "female" product has no slit or hole. Only the "male" mesh is provided in the heavy weight mesh. The *P3 Evolution* version is similar but ultra lightweight (Fig. 7.110). *ProLite* and *ProLite Ultra* are available in the non-keyhole and the keyhole prod-

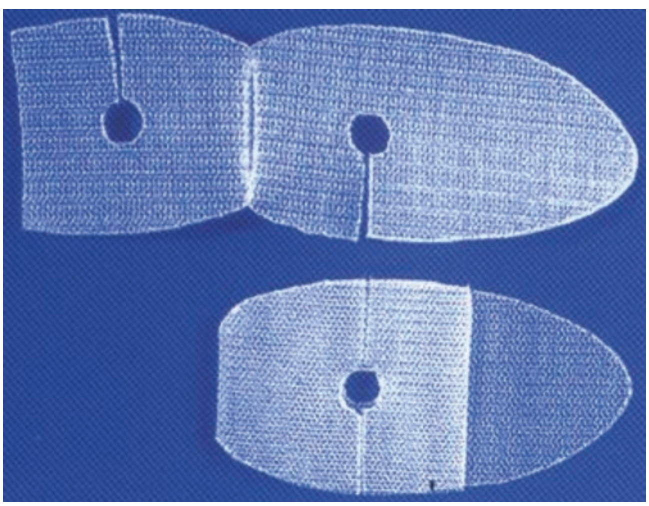

Fig. 7.103 Angimesh XCO

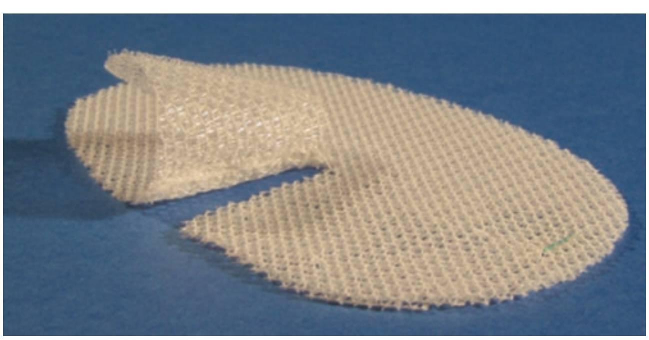

Fig. 7.104 Parietex ProGrip polyester (All rights reserved. Used with Permission of Medtronic)

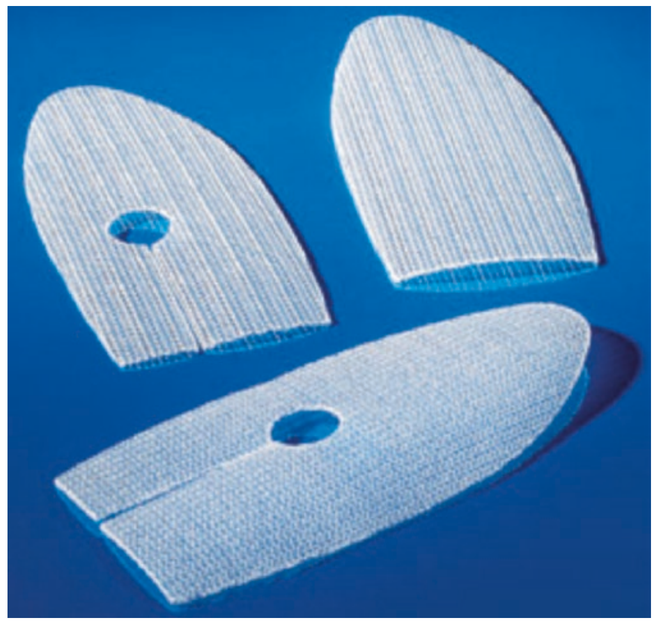

Fig. 7.105 Hertra 1 (upper left), 2 (lower), 2A (upper right)

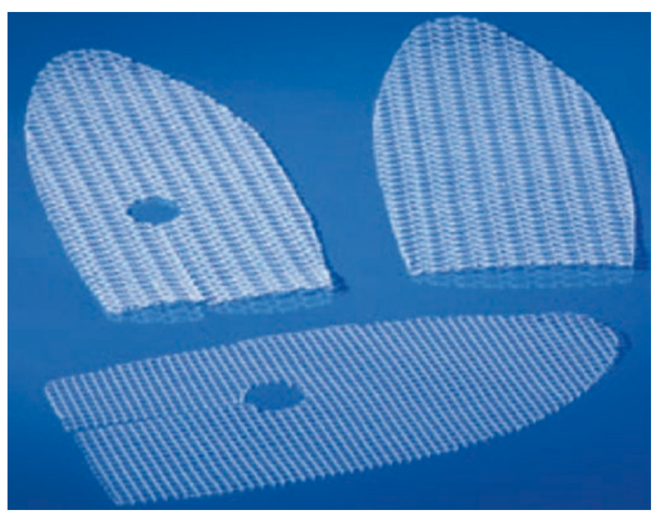

Fig. 7.106 Hertra 6 (upper left), 6A (upper right), 7 (lower)

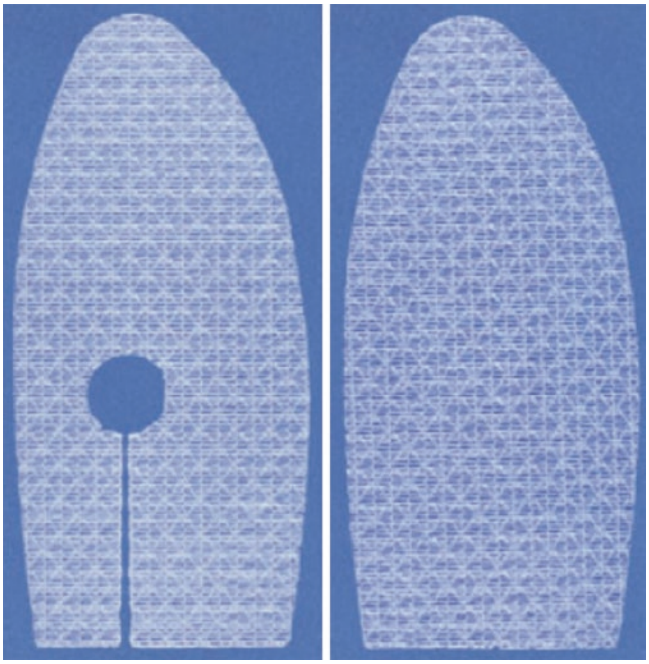

Fig. 7.107 Hertra 9 (left), 9A (right)

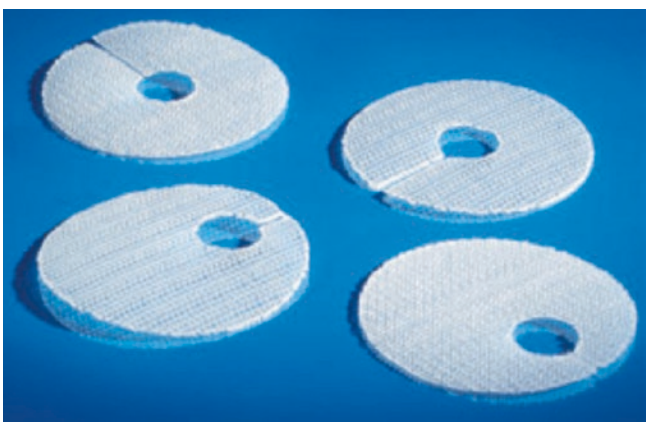

Fig. 7.108 T4 plugs

Fig. 7.109 P3

uct like most of these here but are also available in a unique shape with one side larger than the other.

SM2+ is a bidimensional polyester preshaped product (Fig. 7.87). It is a combination product of PP and PUR and is recommended for all hernias, although its shape lends itself to inguinal repair. *SM3* and *SM3+* have been described in the flat mesh section (Figs. 7.88 and 7.89). They are configured in several sizes for open inguinal hernia repair. *TiPATCH* is made of the same material as TiMESH but this has two overlapping pieces of the mesh to cover behind the cord structures of the inguinal hernia repair (Fig. 7.111). It is PPM that is titanized. *Wings* mesh also has overlapping portions of the product to allow exit of the cord and potentially be used as a sutureless technique (Fig. 7.112).

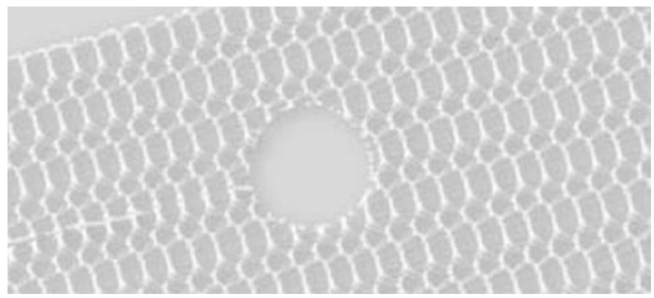

Fig. 7.110 P3 evolution

Fig. 7.111 TiPATCH

Combination Flat Synthetic Prosthetics

This grouping of these products is made because there is a permanent portion of these materials and an absorbable component to the product. These prostheses are generally not meant to contact any viscera and do not possess a specific shape. (Table 7.16)

Adhesix, Parietene ProGrip, and *Parietex ProGrip* all have self-attaching portions of the prosthesis so that once placed onto the tissue surface, they will fixate themselves (Figs. 7.104 and 7.113). These "gripping portions" are absorbable. The permanent portions of Adhesix and Parietene ProGrip are made of PP while the Parietex ProGrip is POL. *Adhesix* has a coating on one side that is made of polyvinylpyrrolidone and polyethylene glycol. This coating turns into an adhesive gel when it comes into contact with both heat and humidity. *Parietex ProGrip Laparoscopic* is a flat sheet of polyester that has microgrips of polylactic acid that lasts >18 months (Fig. 7.114). It differs from the other ProGrip products in that it has a green portion to delineate the medial aspect of the mesh and has a light coating of collagen to make manipulation during laparoscopic use easier.

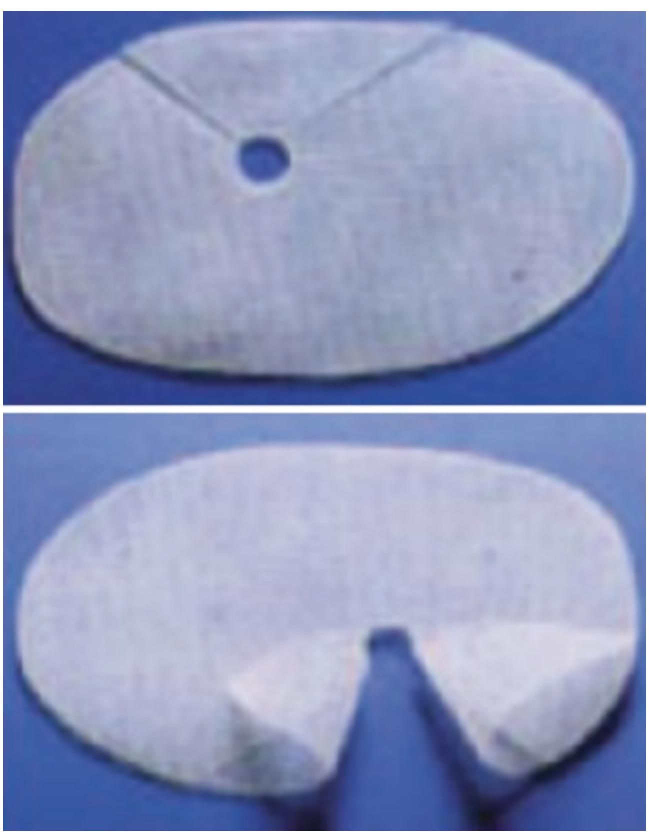

Fig. 7.112 Wings

Table 7.16 Combination products

Adhesix, Davol, Inc., Warwick, RI, USA
Easy Prosthesis Partially Absorbable PAF, TransEasy Medical Tech.Co.Ltd, Beijing, China
Easy Prosthesis Partially Absorbable PAS, TransEasy Medical Tech.Co.Ltd, Beijing, China
4D Mesh, Cousin Biotech, Wervicq-Sud, France
4D Mesh Ventral, Cousin Biotech, Wervicq-Sud, France
Hybridmesh, Herniamesh, Torino, Italy
Parietene ProGrip, Medtronic, Minneapolis, MN, USA
Parietex ProGrip, Medtronic, Minneapolis, MN, USA
Parietex ProGrip Laparoscopic, Medtronic, Minneapolis, MN, USA
TiMesh, GfE Medizintechnik, Nuremburg, Germany
Vypro, Ethicon, Inc., Somerville, NJ, USA
Vypro II, Ethicon, Inc., Somerville, NJ, USA
Ultrapro, Ethicon, Inc., Somerville, NJ, USA
Ultrapro Advanced, Ethicon, Inc., Somerville, NJ, USA

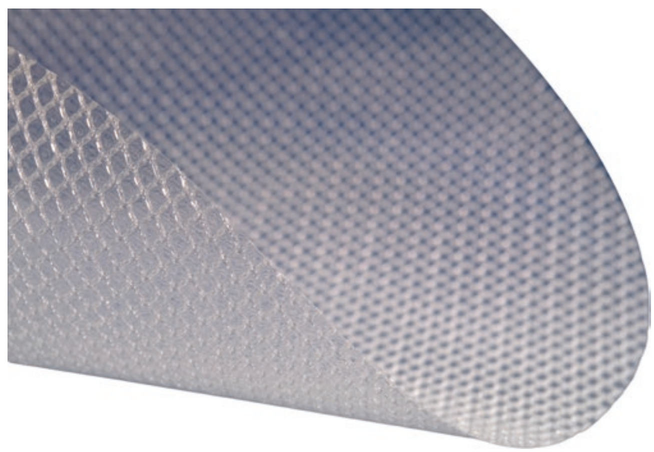

Fig. 7.113 Adhesix

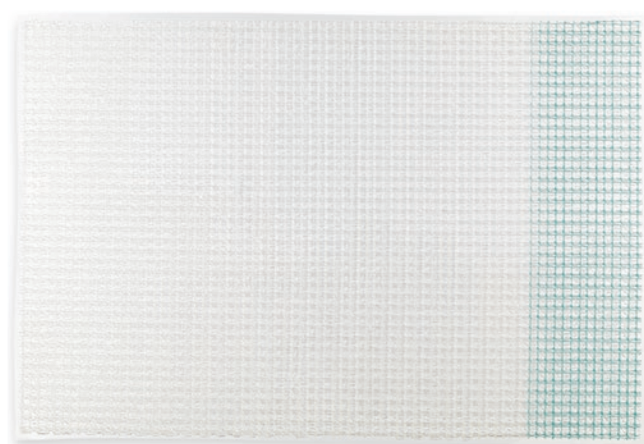

Fig. 7.114 Parietex ProGrip laparoscopic (All rights reserved. Used with Permission of Medtronic)

Easy Prothes Partially Absorbable is a partially absorbable product (Fig. 7.115). It is a combination of PP and poly(glycolide-cocaprolactone) [PGCL] monofilaments. The PGCL portion will be completely absorbed within 90–120 days. It is available in two versions, both of which have a PP weight of 30 g/m^2, which is the final weight of the material after degradation of the absorbable material. The difference lies in the weight of the PGCL, which are 30 g/m^2 in the *PAF* material and 60 g/m^2 in the *PAS* product. *4D Mesh* is made of a base of a 25% PP base with the remainder of resorbable PLLA (Fig. 7.116). It is approximately 30gm/m^2 postabsorption. The design shown is for open inguinal hernia repair but there is also a preshaped product for laparoscopic repair (Fig. 7.117). The *4D Ventral* is a flat sheet and differs from the 4D mesh in that it is 40% PP and 60% PLLA (Fig. 7.118). *Hybridmesh* is a quadraxial mesh co-knitted with 25% non-absorbable PP and 75% monofilament PLLA (Fig. 7.119). This results in an implantation weight of 80gm/m^2 and a final weight of 20 g/m^2 after 18–24 months.

Timesh is one of the few products in this section that can be placed against the viscera (Fig. 7.120). The materials, *Vypro* and *Vypro II* are actually a combination of PP and the absorbable polymer polydioxione (Fig. 7.121). The combination of these materials results in a very pliable and malleable material. Once the polydioxione has been absorbed, the PP that remains has very large interstices into which the fibroblasts and collagen are deposited. The aim of these type of products is the improvement in the abdominal wall compliance that is more normal in function because of the very lightweight PP that remains. *Ultrapro* mesh is a similar concept and is manufactured from approximately equal parts of the absorbable poliglecaprone-25 monofilament fiber and the non-absorbable lightweight PP (Fig. 7.122). A portion of the PP is dyed. The absorbable portion is essentially absorbed by 84 days. *Ultrapro Advanced* is similar to the former product but is designed to allow for more stretch of the abdominal wall, allowing a 2:1

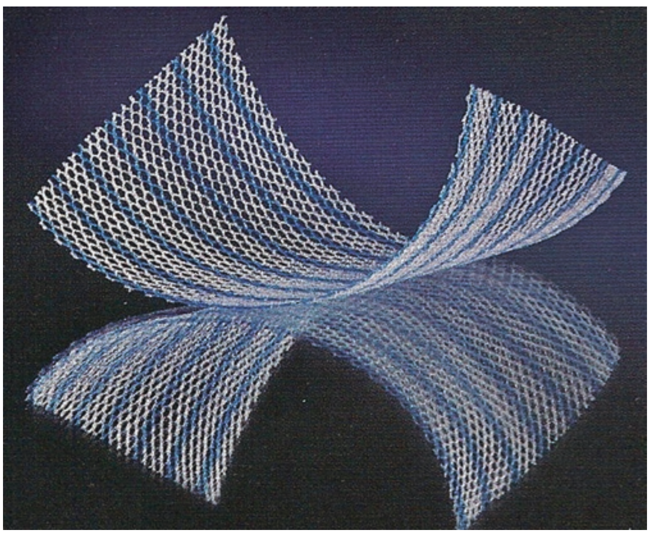

Fig. 7.115 Easy prothes partially absorbable

Fig. 7.116 4D inguinal

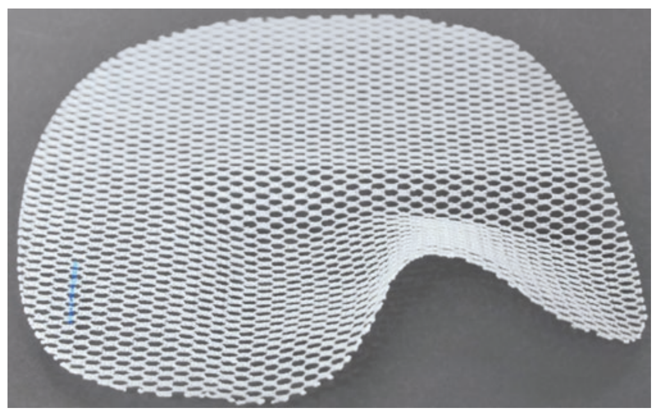

Fig. 7.117 4D laparoscopic

Fig. 7.118 4D ventral

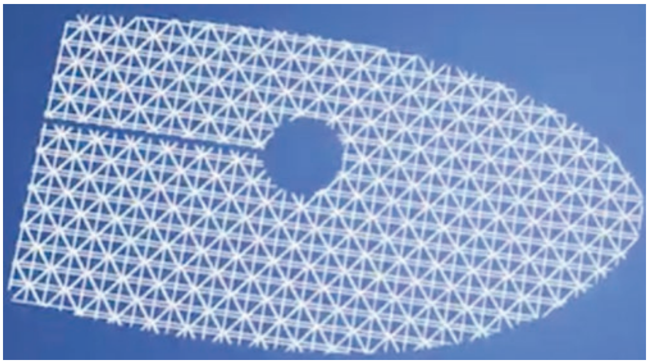

Fig. 7.119 Hybridmesh

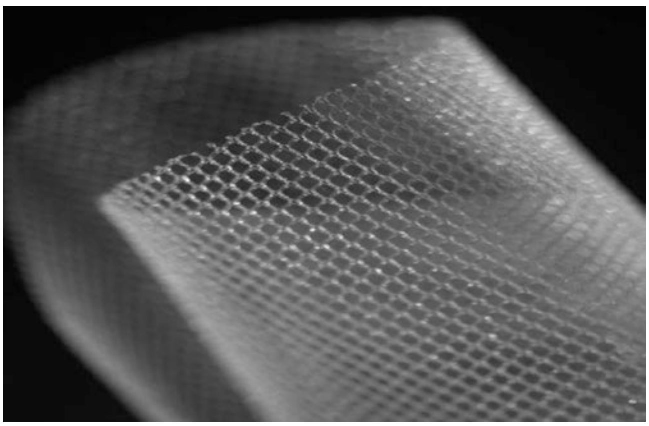

Fig. 7.120 TiMESH

stretch (Fig. 7.123). It stretches to the greatest degree perpendicular to the blue stripes.

Preformed Prosthetic Devices for Open Hernioplasty

These products are inserted into the defect of the fascia that the hernia represents. The repair of inguinal hernias with these products simply involves the insertion of the plug through the fascial defect into the extraperitoneal plane, which is then secured to the edges of the fascia. Additionally, they also employ the use of an overlay of an additional piece of mesh to complete the repair. There are structural differences with these products that alter the concept of each one. Some surgeons also modify these plugs prior to insertion to more completely protect the preperitoneal space. All are of a polypropylene biomaterial with the exception of the Parietex Plug (Table 7.17).

There are several "self-forming" plugs. These are flat, round, and without a hole rather than being preshaped, as one might expect in a true plug-like product. The *Repol Basic plug* is one of these (Fig. 7.124). The makers of such devices believe that this is a "one-size-fits-all" concept in that they can be utilized in any size of a fascial defect. Other products that correspond to this design are the *Self-Forming Plug,* the *SurgiMesh WN Easy Plug* and the *T1* plugs. (Figs. 7.125–7.127). The *Self-Forming Plug* differs from the other two single layer products in that it is made

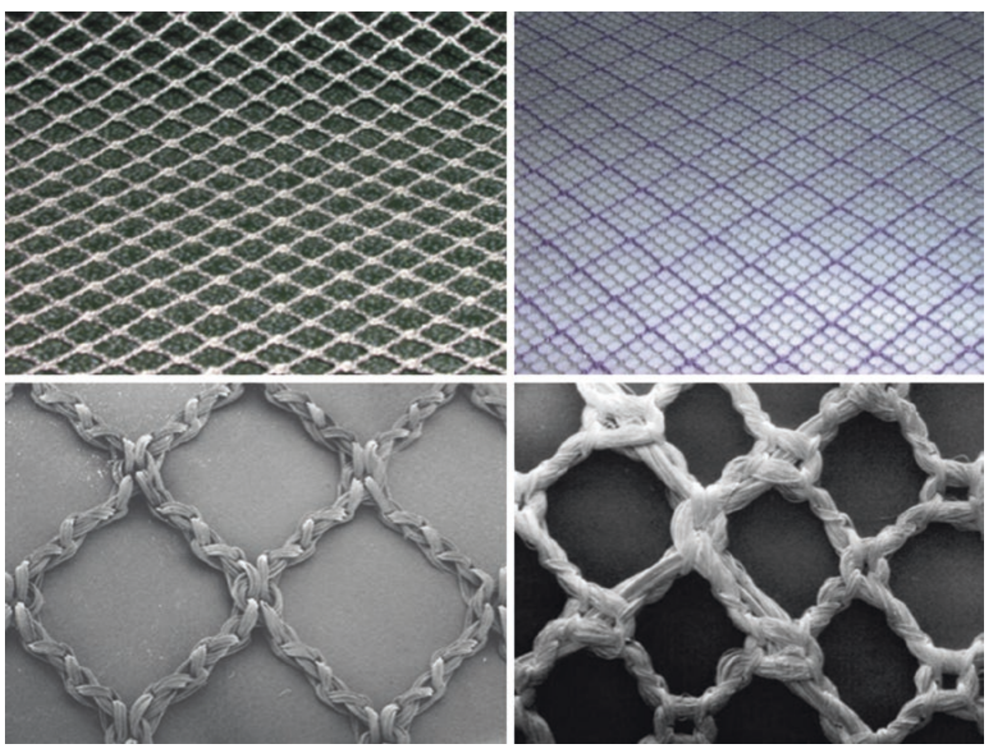

Fig. 7.121 Vypro and Vypro II (Image courtesy of Ethicon, Inc.)

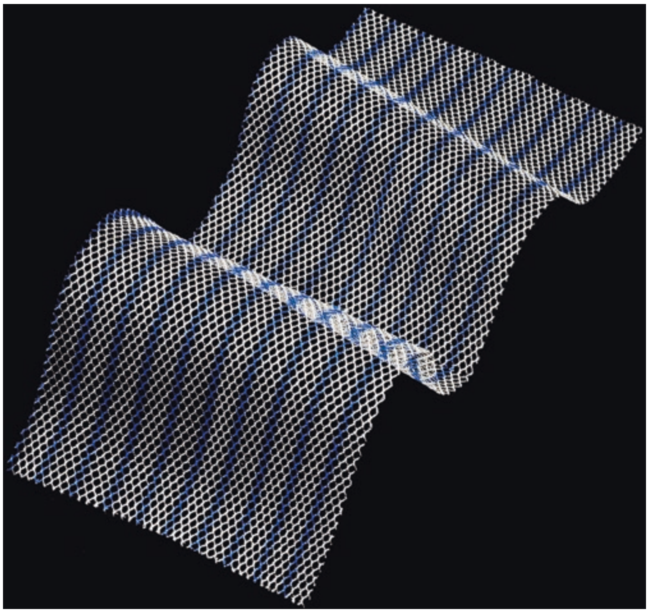

Fig. 7.122 Ultrapro flat mesh (Image courtesy of Ethicon, Inc.)

Fig. 7.123 Ultrapro advanced (Image courtesy of Ethicon, Inc.)

Table 7.17 Plug type products

Bard Mesh Dart, Davol, Inc., Warwick, RI, USA
Repol Basic plug, Angiologica, S. Martino Sicc, Italy
Easy Prothes Partially Absorbable, TransEasy Medical Tech.Co. Ltd, Beijing, China
Easy Prothes Plug, TransEasy Medical Tech.Co.Ltd, Beijing, China
Easy Prothes Light Plug, TransEasy Medical Tech.Co.Ltd, Beijing, China
4D Dome, Cousin Biotech, Wervicq-Sud, France
NeT Plug and Patch, Herniamesh, Torino, Italy
Parietex Plug and Patch System, Medtronic, Minneapolis, MN, USA
PerFix Plug, Davol Inc., Warwick, RI, USA
Perfix Light Plug, Davol Inc., Warwick, RI, USA
Plug P, Microval, Saint-Just-Malmont, France
Plug S, Microval, Saint-Just-Malmont, France
Premilene Mesh Plug, B. Braun Melsungen AG, Melsungen, Germany
Proloop Plug, Getinge Group, Wayne, NJ
Repol Plug Cap, Angiologica, S. Martino Sicc., Italy
Repol Plug Flower, Angiologica, S. Martino Sicc., Italy
Self-Forming Plug, Getinge Group, Wayne, NJ
SMPX, THT Bio-science, Montpelier, France
SMPH2, THT Bio-science, Montpelier, France
SurgiMesh WN Easy Plug, Aspide Medical, St. Etienne, France
SurgiPro Plug, Medtronic, Minneapolis, MN, USA
T1 Plug, HerniaMesh, S.R.L., Torino, Italy
T2 Plug, HerniaMesh, S.R.L., Torino, Italy
T3 Plug, HerniaMesh, S.R.L., Torino, Italy
TB plug—Di.pro Medical Devices, Torino, Italy
TEC-T plug—Di.pro Medical Devices, Torino, Italy
TiLENE plug, GfE Medizintechnik, Nuremburg, Germany WEB
TiPLUG—GfE Medizintechnik, Nuremburg, Germany WEB
TP plug, Di.pro Medical Devices, Torino, Italy
Ultrapro Comfort Plug, Ethicon Inc., Somerville, NJ, USA

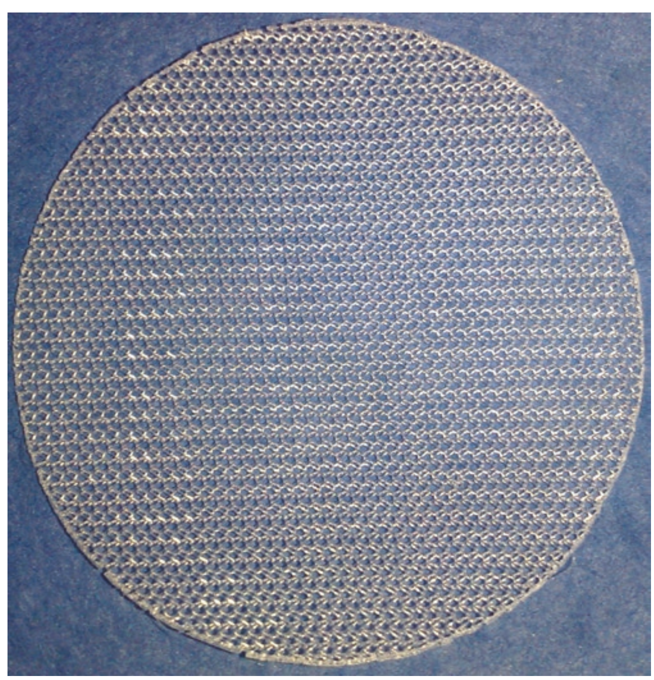

Fig. 7.124 Repol basic

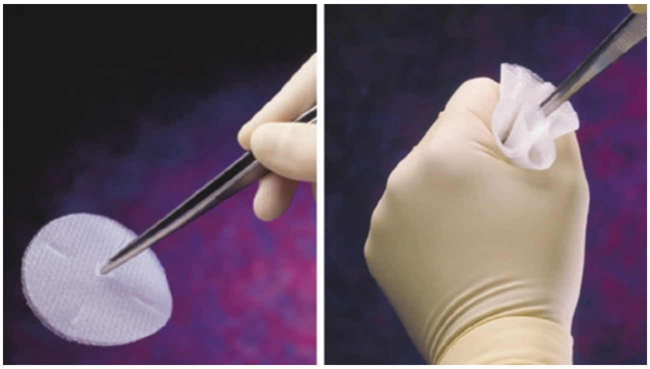

Fig. 7.125 Self-forming plug

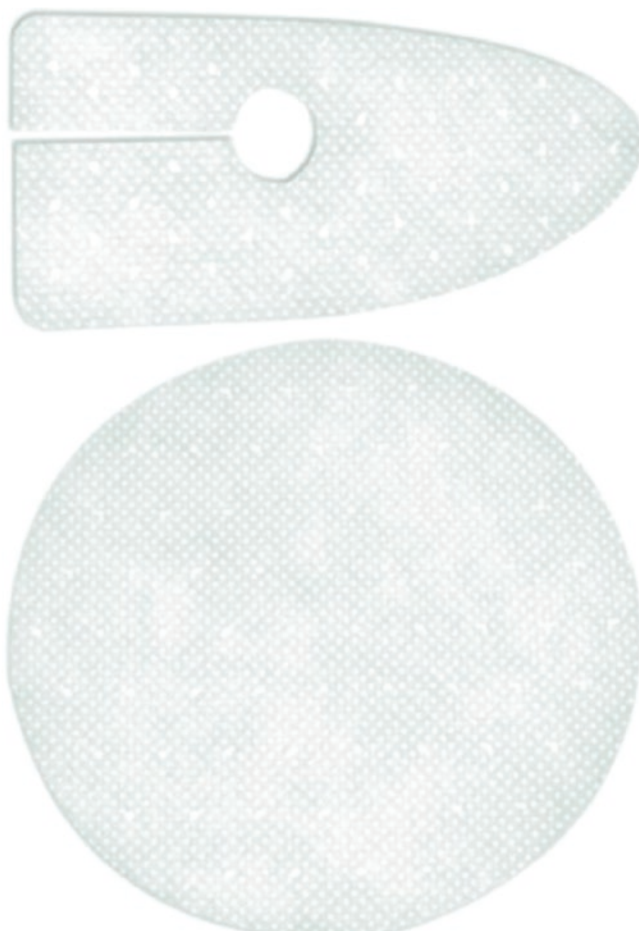

Fig. 7.126 SurgiMesh WN easy plug

of three circular flat meshes in either the ProLite and ProLite Ultra meshes. These are bonded together with a tab on one surface to allow for the grasping of the product by forceps during insertion. This is still soft and pliable so that it assumes the shape of the defect rather than forcing itself into defect. It is available in different sizes. The *Parietex Plug* is available in a 6 or 8 cm size.

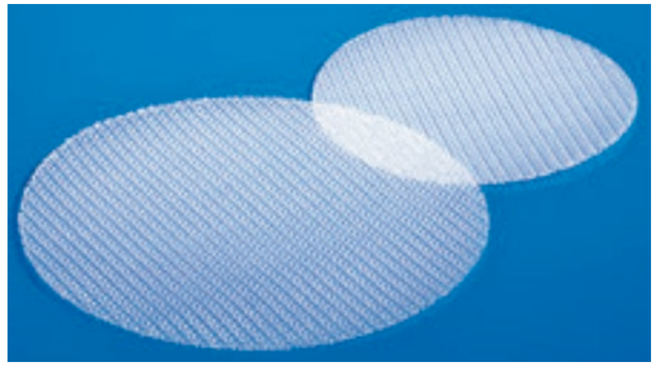

Fig. 7.127 T1

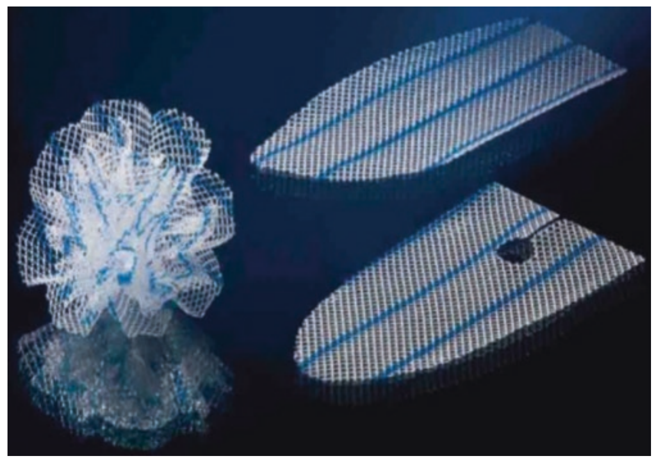

Fig. 7.128 Easy prothes light plug

Fig. 7.129 Easy prothes plug

The *Easy Prothes Plug* is a traditionally designed plug with petals within it. These can be modified, if needed, depending upon the choice of the surgeon. It is available in the 60 g/m^2 and the 40 g/m^2 versions (Figs. 7.128 and 7.129). The *4D Dome* is different from all of the other plug type devices. It is a single layer of PP but it is shaped into a rounded, rather than a pointed, shape (Fig. 7.130). It is constructed of two products, 87% poly-L-lactic acid (absorbable) and 13% polypropylene. The insertion and fixation is the same as the more traditional plugs. Another unique design is that of the *NeT Plug and Patch,* which has the plug portion of the device incorporated into the patch itself (Fig. 7.131). This is designed to eliminate the potential migration that has been rarely seen with plugs. *Parietex Plug and Patch System* is constructed of monofilament polyester and polylactic acid and is therefore partially absorbable (Fig. 7.132). There is another version of this product, the *Parietex Plug Collar with Grips* (Fig. 7.133). This plug has a section on the collar that is of the microgrips similar to that of the Parietex ProGrip products described earlier in the chapter.

The *PerFix Plug* is available in four different sizes (Fig. 7.134). This is the most mature of these commercial products. Because of the trend to lighter weight PP in the repair of hernias, it is also available in the *PerFix Light Plug* (Fig. 7.135). It, too, is available in 4 different sizes. These allow

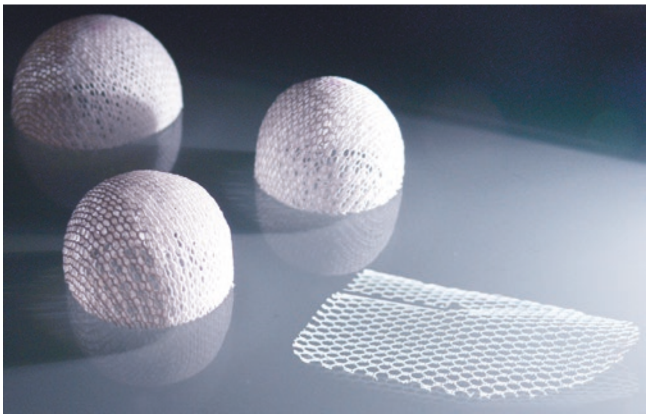

Fig. 7.130 4D dome

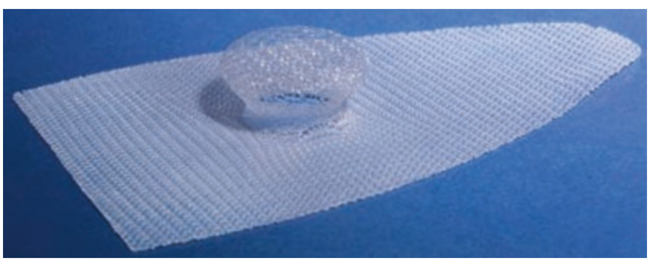

Fig. 7.131 NeT plug and patch

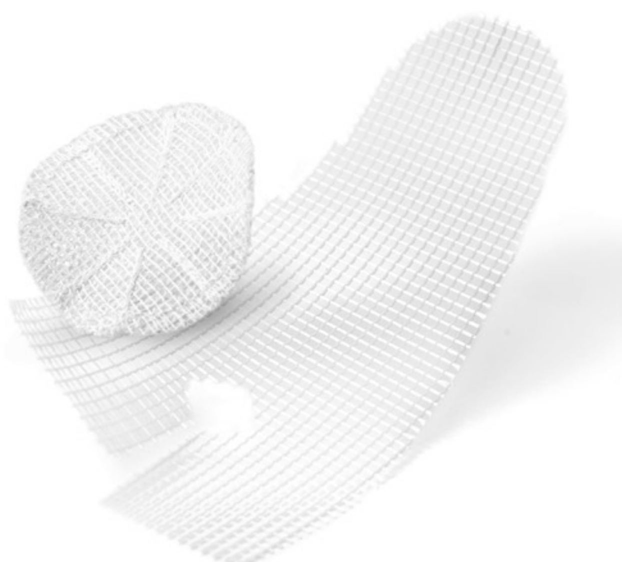

Fig. 7.132 Parietex plug and patch system (All rights reserved. Used with Permission of Medtronic)

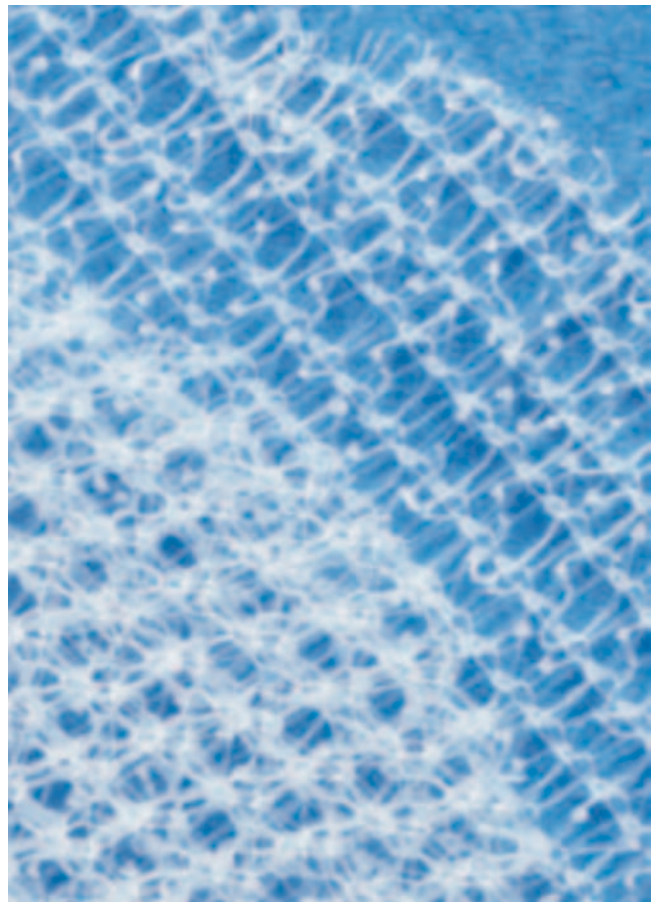

Fig. 7.133 Parietex plug collar with grips (All rights reserved. Used with Permission of Medtronic)

Fig. 7.134 Perfix

for modification of the plug in that the surgeon can remove the inner petals at the time of implantation. Some surgeons have reported good results with completely opening the petals in the preperitoneal space [13]. Other products that are also fluted but do not allow any modification are the *Premilene Mesh Plug* and the *Repol Flower* (Figs. 7.136 and 7.137). The *Proloop Plug* is a pointed type of plug but it lacks any internal structure so it, too, cannot be modified (Fig. 7.138). As shown in the photo, this product is quite different in appearance than the other plug devices. Although preformed into a cylindrical shape, it is very supple and conforms to the defect into which it is inserted. *Plug P* is a PP plug that can be adjusted with the pull of the string to confirm to the inguinal opening (Fig. 7.139). *Plug S* differs from the Plug P in that it is similar to the other unadjustable preformed and preshaped plugs listed in this section.

Surgipro mesh that was described above (Table 7.11) is also available as *Surgipro plug and patch* system (Fig. 7.140). *SMPX* and *SMPH2* are the standard weight or lightweight version of a plug. The *SMPX* is adjustable while the other is not (Fig. 7.141). There is another *SurgiMesh WN EasyPlug* but this device is a preformed plug with variable geometry and is adjustable to the size of the defect (Fig. 7.142). A purse-string suture is part of the device to help in sizing of the plug.

The *Bard Mesh* Dart, *Repol Plug Cap*, and the *T2 Plug* represent a concept that combines a small piece of a round, flat PPM atop a cone shaped plug (Figs. 7.143, 7.144, and 7.145). These devices are also significantly different from all of the other plugs. The *T3 Plug* has a rectangular piece of mesh affixed to it (Fig. 7.146). There are differing

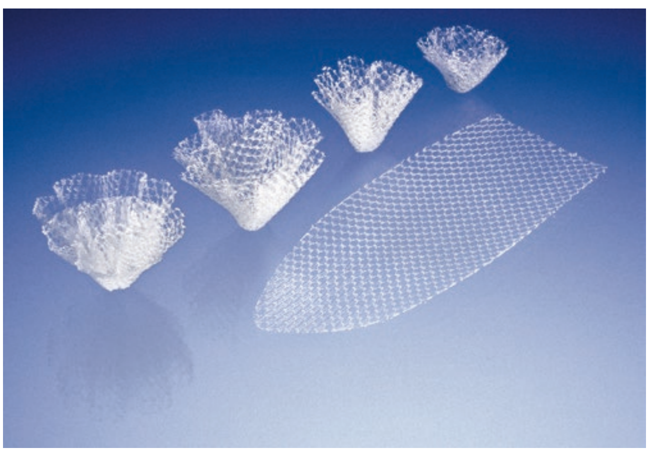

Fig. 7.135 Perfix light

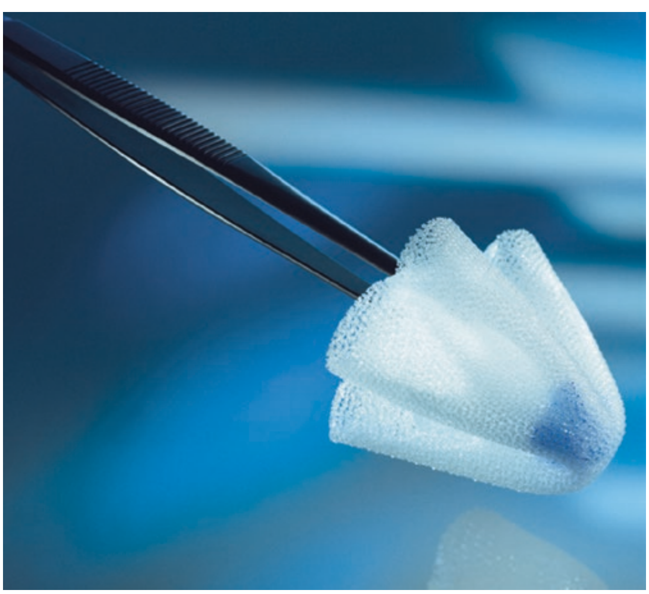

Fig. 7.136 Premilene mesh plug

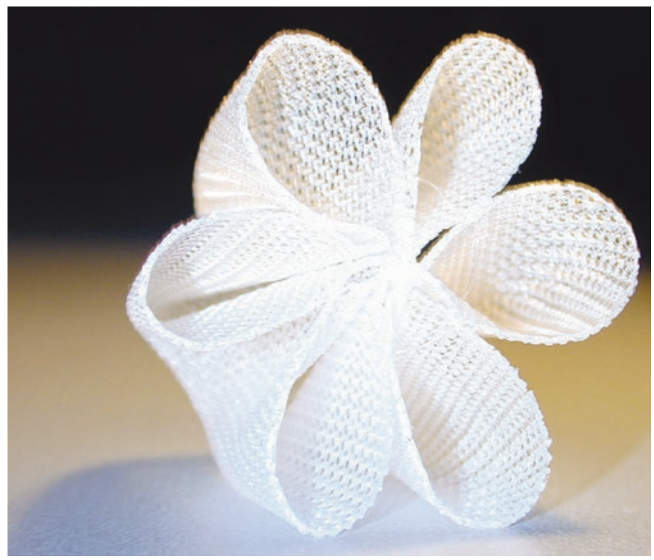

Fig. 7.137 Repol flower

Fig. 7.138 Proloop

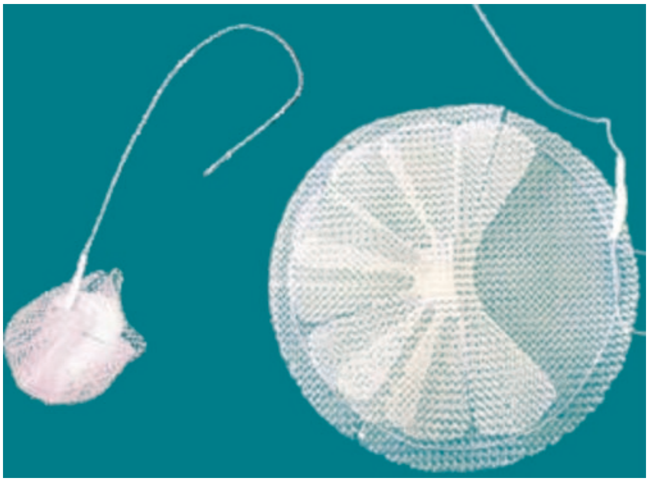

Fig. 7.139 Plug P

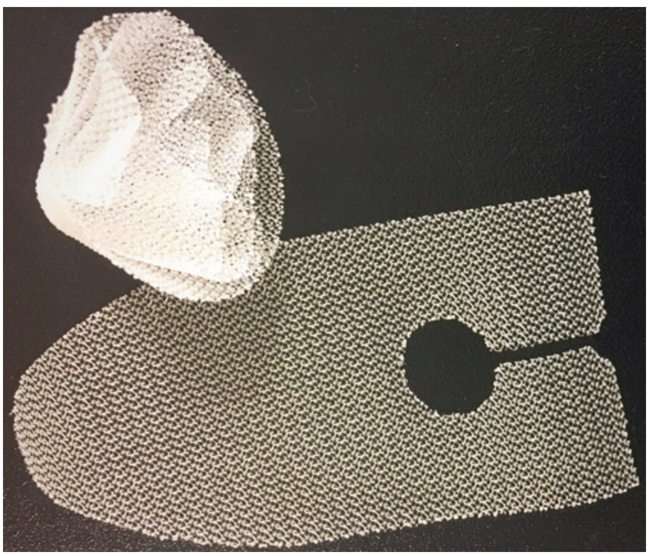

Fig. 7.140 Surgipro plug (All rights reserved. Used with Permission of Medtronic)

Fig. 7.141 SMPX

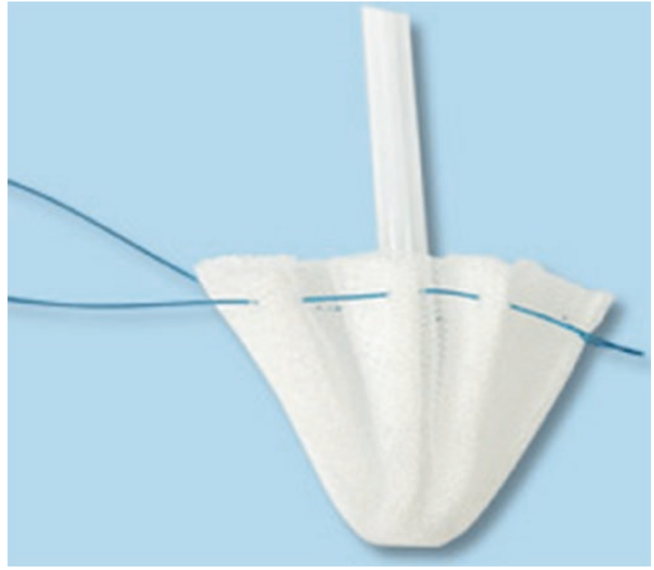

Fig. 7.142 SurgiMesh WN EasyPlug

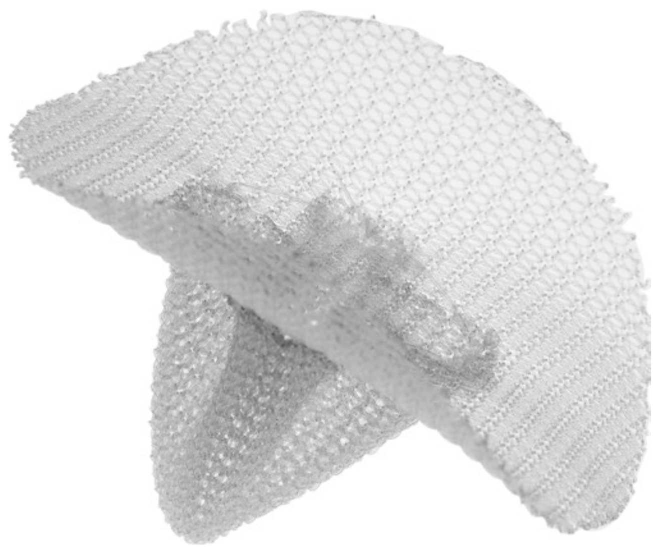

Fig. 7.143 Bard mesh dart

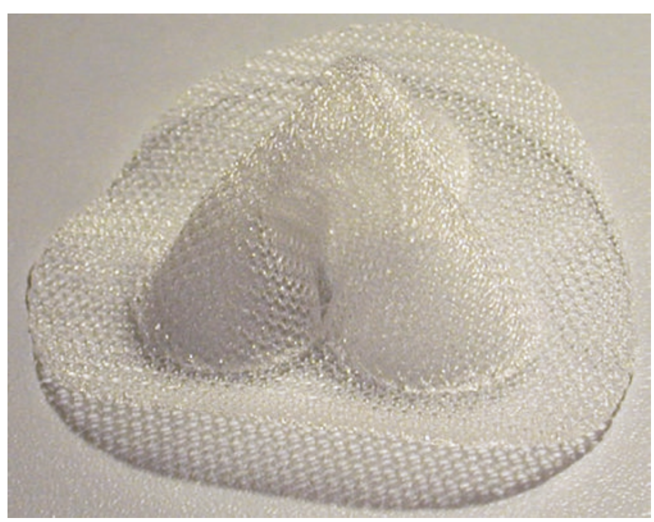

Fig. 7.144 Repol plug cap

sizes that are chosen based upon the size of the defect. With any of these three devices, one can insert the plug component into the preperitoneal space and use the flat portion to sew to the fascial edges as a small onlay or underlay.

The *TEC-T* plug is made in the conical shape and is fluted as are most plugs but of an ultra lightweight PP material (Fig. 7.147, left). There is a second design of the *TB* plug that has lightweight petals and a medium weight PPM atop the cone (Fig. 7.147, right). The *TP* plug is another of the "self-forming" plugs of PPM (Fig. 7.148). The *TiLENE Plug* is of the TiMesh product that has been previously described (Fig. 7.149). It is a flat product that will conform to the hernia defect as it is inserted but differs in appearance from all of the other "self-forming" plugs. The outer layers of the petals are medium weight PP and the inner petals are a lighter weight PP. *TiPLUG* is also made of TiMESH (Fig. 7.150). It has a flap through which the cord structures are to be placed. As such, it differs from all of the other plugs listed. The *TP* plug is a rounded mesh with or without an eccentric hole and with or without a slit to that hole. The *Ultrapro Comfort Plug* is made from the previously described Ultrapro mesh (Fig. 7.151). The absorbable and nonabsorbable portions are connected by the absorbable poliglecaprone-25 fibers. It is supplied with an onlay patch.

Fig. 7.145 T2

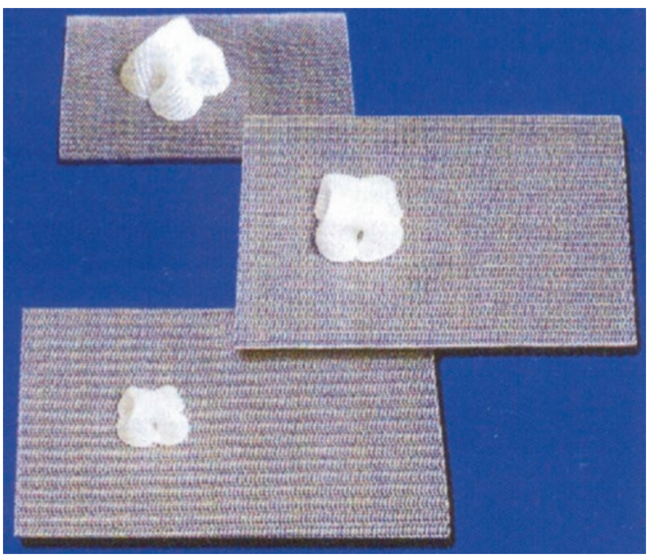

Fig. 7.146 T3

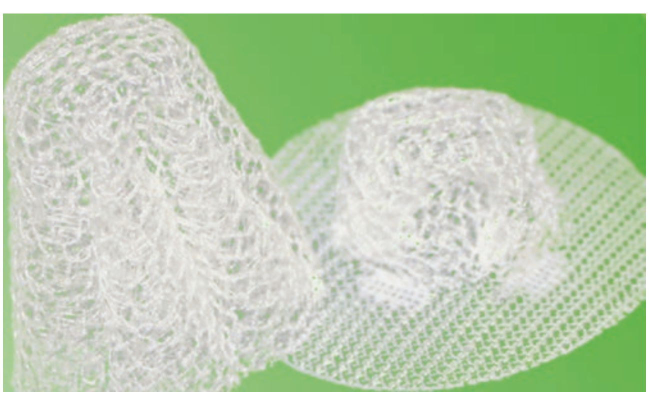

Fig. 7.147 TEC-T (left) and TB (right)

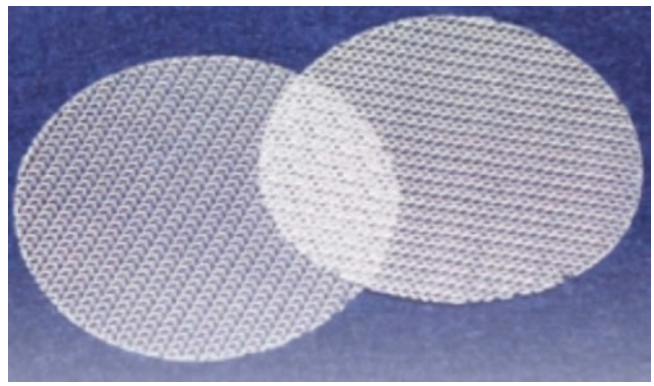

Fig. 7.148 TP

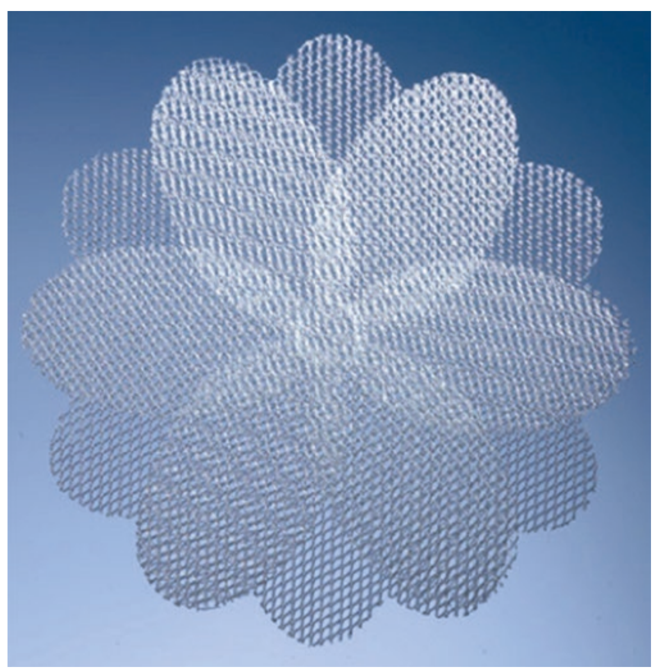

Fig. 7.149 TiLENE Plug

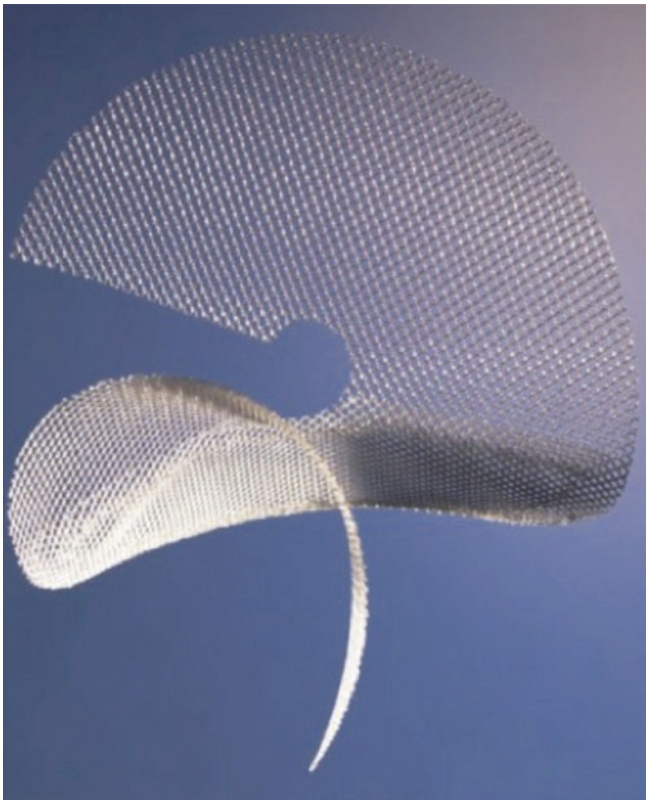

Fig. 7.150 TiPLUG

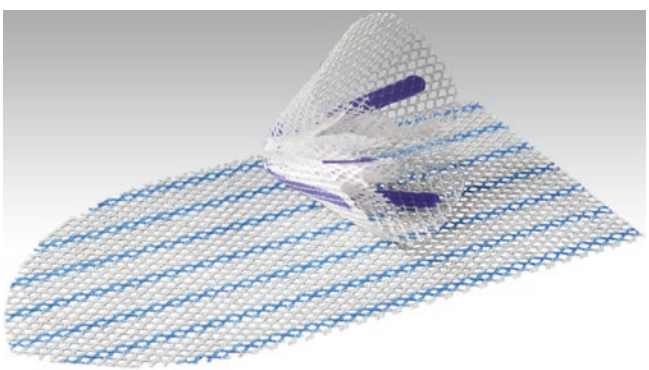

Fig. 7.151 Ultrapro comfort plug and patch (Image courtesy of Ethicon, Inc.)

Extraperitoneal Prosthetic Devices for Open Inguinal Hernioplasty

The posterior repair of open inguinal hernias is based upon the approach into the preperitoneal space. The use of a preformed prosthetic device in this space represents an emulation of the Stoppa repair and the giant prosthetic repair of the visceral sac of Wantz. The products that have been manufactured for this concept are not "giant" prostheses, however (Table 7.18).

Table 7.18 Extraperitoneal inguinal devices

Easy Prothes Preperitoneal Repair Patch, TransEasy Medical Tech. Co.Ltd, Beijing, China
Easy Prothes Light Preperitoneal Repair Patch, TransEasy Medical Tech.Co.Ltd, Beijing, China
Easy Prothes Partially Absorbable Preperitoneal Repair Patch, TransEasy Medical Tech. Co. Ltd, Beijing, China
Oval Preshaped Mesh, Herniamesh, Torino, Italy
OnFlex, Davol Inc., Warwick, RI, USA
Modified OnFlex, Davol Inc., Warwick, RI, USA
PB, Microval, Saint-Just-Malmont, France
Prolene Hernia System, Ethicon Inc., Somerville, NJ, USA
Prolene 3D Patch, Ethicon Inc., Somerville, NJ, USA
Rebound HRD Shield, ARB Medical, Minneapolis, MN, USA
*SM2+,*THT Bio-Science, Montpelier, France
T5 mesh, Herniamesh, Torino, Italy
Ultrapro Hernia System, Ethicon Inc., Somerville, NJ, USA

The *Easy Prothes Preperitoneal Repair Patch* also has an underlay portion but instead of the flat sheet of PP, there are petals that can be stitched to the fascial edges of the hernia itself (Fig. 7.152). This is similar to the plug and patch repair as the product is supplied with an onlay patch to place underneath the external oblique. There is a lightweight version as the *Easy Prothes Light Preperitoneal Repair Patch* that has straps and pockets to facilitate placement (Fig. 7.153). *Easy Prothes Partially Absorbable Preperitoneal Repair Patch* is similar to these products but is constructed of a partially absorbable material (PP and PGCL) that was described earlier in this chapter (Table 7.16). This is available as a round patch with four petals or with an oval base with pockets and a tether (Figs. 7.154 and 7.155).

Oval Preshaped mesh is to be used in the Kugel technique of extraperitoneal hernia repair (Fig. 7.156). It is a very heavy and rigid material. The *Onflex* is designed for placement exclusively in the preperitoneal space (Fig. 7.157). It has an added incomplete "ring" of polydioxanone. The mesh can be cut between this opening to allow for exit of the cord structures, if desired. It also is available as the *Modified Onflex* with an attached tether of PP and is to be used with an onlay (Fig. 7.158). Both of these are available in two different sizes.

The *Prolene Hernia System* is similar to the Easy Prothes (Fig. 7.152) in that it is designed as a connected another mesh product (Fig. 7.159). The difference between the two products is that the older Prolene Hernia System (PHS) has a connector piece that attaches the rounded underlay (extraperitoneal) portion and the elliptical (onlay) portion. There are three sizes of the PHS, medium, large, and extended. The choice of the size will depend upon the size and type of defect as well as the size of the patient and location of the hernia. These have also been used for umbilical and ventral hernias. *SM2+* has previously

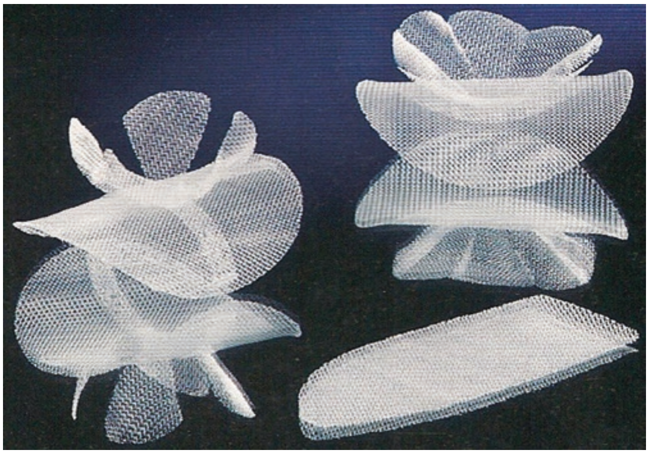

Fig. 7.152 Easy prothes preperitoneal repair patch

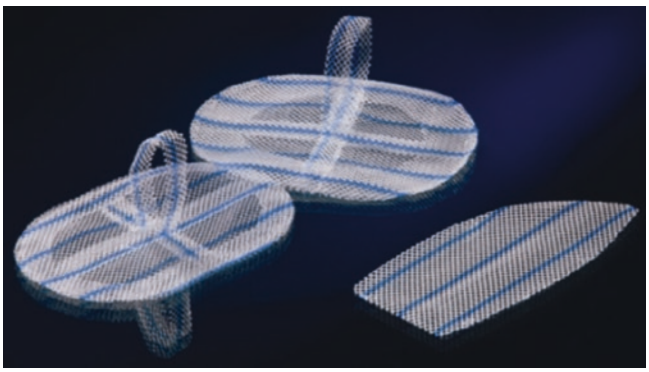

Fig. 7.153 Easy prothes light preperitoneal repair patch

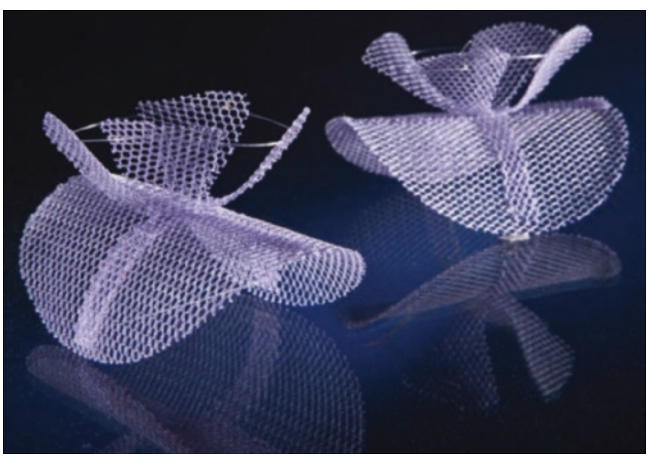

Fig. 7.154 Easy prothes partially absorbable preperitoneal repair patch—round

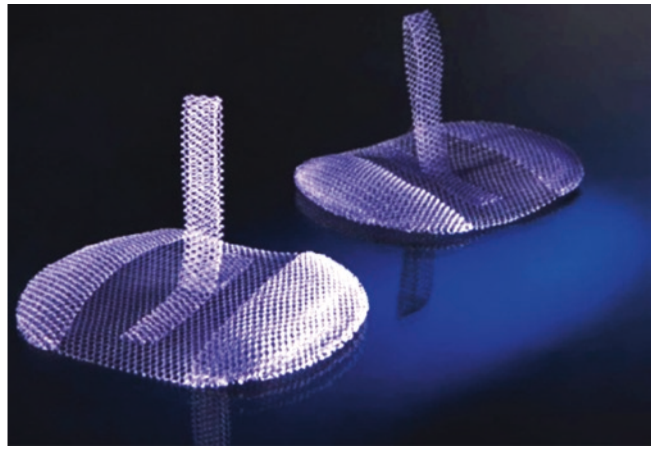

Fig. 7.155 Easy prothes partially absorbable preperitoneal repair patch—oval

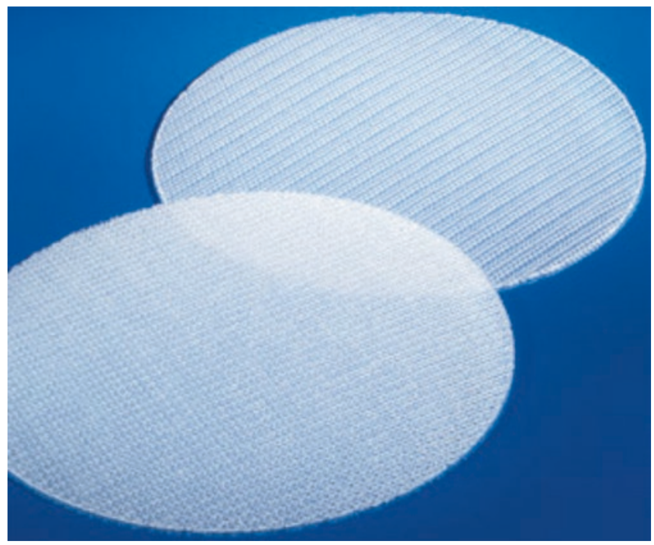

Fig. 7.156 Oval Preshaped

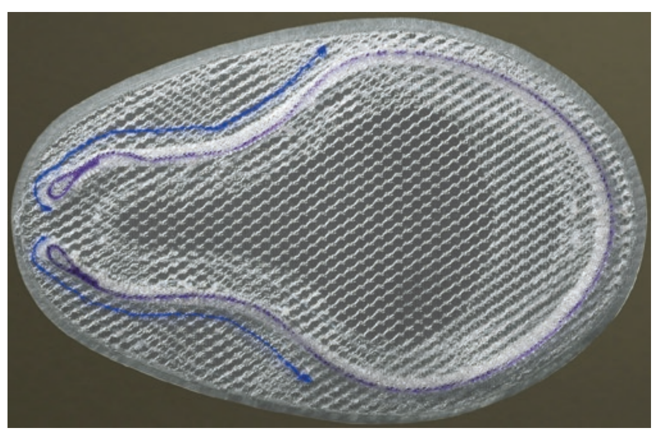

Fig. 7.157 Onflex

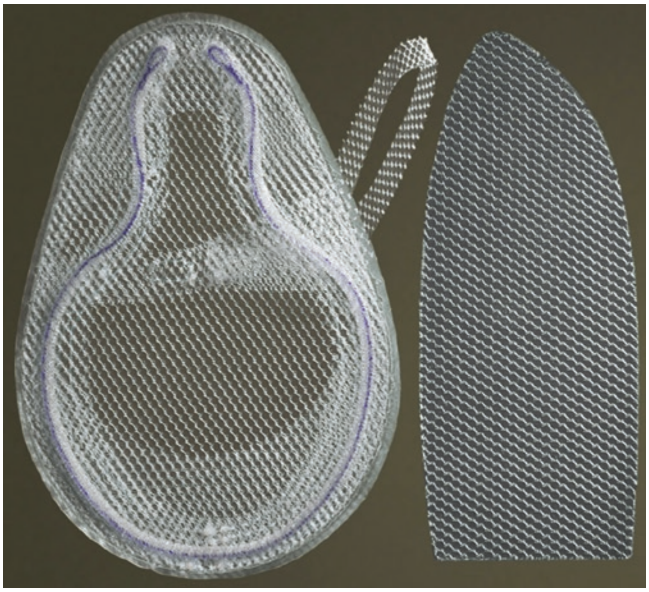

Fig. 7.158 Modified Onflex

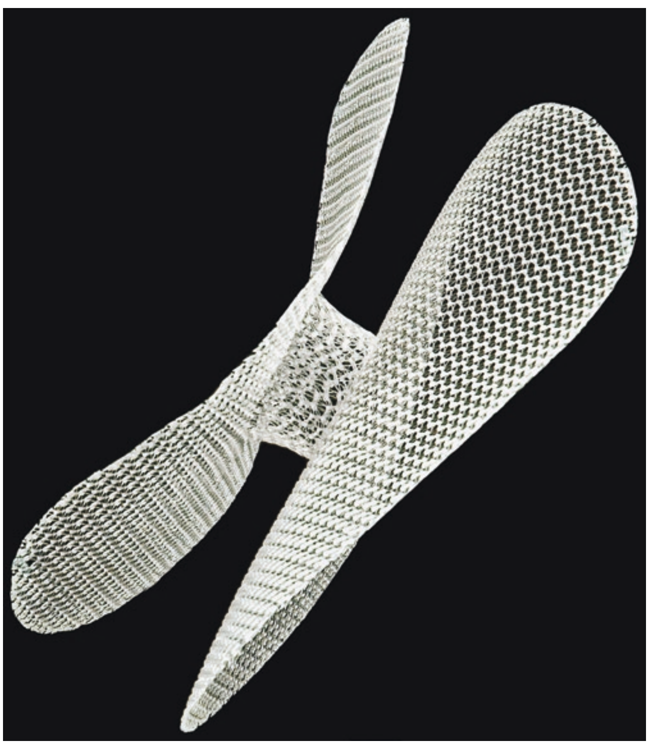

Fig. 7.159 Prolene hernia system (Image courtesy of Ethicon, Inc.)

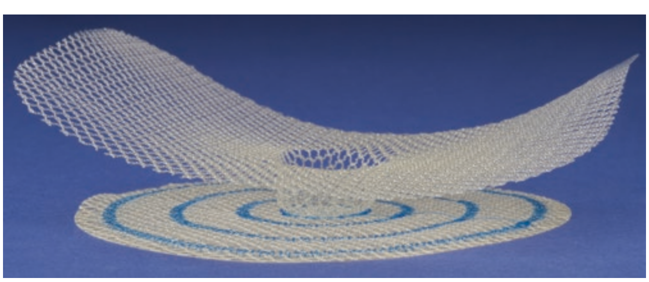

Fig. 7.160 Ultrapro hernia system (Image courtesy of Ethicon, Inc.)

been described in the flat mesh device section above. It is polyester and impregnated PUR (Fig. 7.87). The *Ultrapro Hernia System* is a combination product that is made from Ultrapro flat mesh that has the identical shape as the PHS that has additionally incorporated poliglecaprone-25 into the underlay portion (Fig. 7.101). This absorbable component of the Ultrapro material will leave behind a very lightweight PPM to repair the hernia (Fig. 7.160).

The *Prolene 3D Patch* is a three-dimensional device, which possesses two different portions of this product (Fig. 7.161). The diamond shaped portion is inserted into the preperitoneal space. The single pull of the suture causes the diamond to flatten out underneath the tranversalis fascia. The overlay portion is then secured as in the tension-free repairs. It is available in two sizes of the diamond portion and with or without a pre-shaped overlay. The *PB* inguinal implant possesses characteristics of the PHS and the Prolene 3D patch (Fig. 7.162). It is available in standard (90 gm/m^2) or light weight (60 gm/m^2) and in three different sizes. With these two corrections, this should not read “The *PB* inguinal implant possesses characteristics of the PHS and the Prolene 3D patch (Fig. 7.162). It is available in standard (90 gm/m^2) or light weight (60 gm/m^2) and in three different sizes. *Rebound HRD Shield* is a rather unique concept in hernia repair (Fig. 7.163). This device is designed to maintain the shape of the product after introduction into the preperitoneal space by the incorporation of a self-expanding nitinol alloy frame at the perimeter of the PP mesh. Because of the presence of this nitinol, this is the only prosthesis that can be visualized on radiologic studies postoperatively. *T5 mesh* is positioned in the extraperitoneal plane and is to be used with one of the other Hertra products (Fig. 7.164). It is preshaped with a keyhole to allow for passage of the cord structures.

Pre-Shaped Products for Laparoscopic/ Robotic Inguinal Hernioplasty

The history of laparoscopic repair of inguinal hernias involved flat meshes of one type or another. This continues to be a frequently used prosthetic product for this operation (Tables 7.11 and 7.12). There are, however, a number of devices that have been constructed for this procedure (Table 7.19). These all attempt to ease the placement of the prosthetic over the myopectineal orifice and/or serve to conform to the anatomic configuration at that site of the repair. These can be placed with either the transabdominal preperitoneal (TAPP) or totally extraperitoneal (TEP) approaches. A few are manufactured to make fixation with any type of fastener unnecessary.

The *3D Anatomic* implant has very deep curves that are designed to exactly fit the curves of the inguino-pelvic anatomy (Fig. 7.165). There is a mark in the inferior internal edge of the prosthetic to aid in positioning as there is a right and left product. For the TEP approach, no fixation required. The *3D Max* and *3D Max Light* products are similar in shape

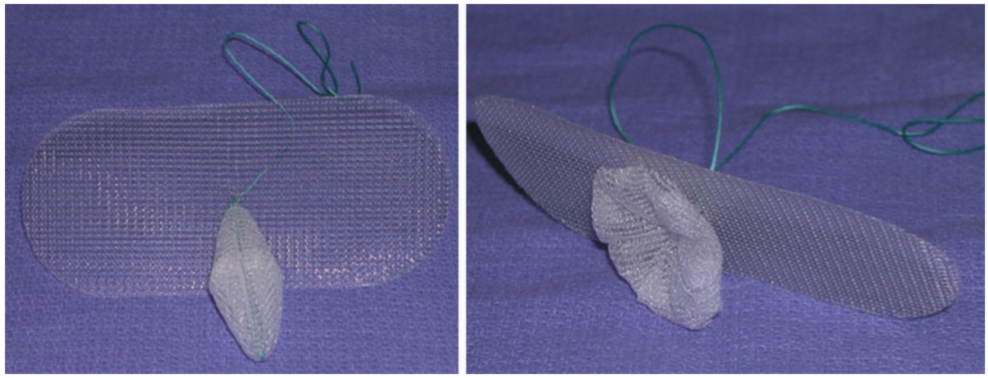

Fig. 7.161 Prolene 3D patch (Image courtesy of Ethicon, Inc.)

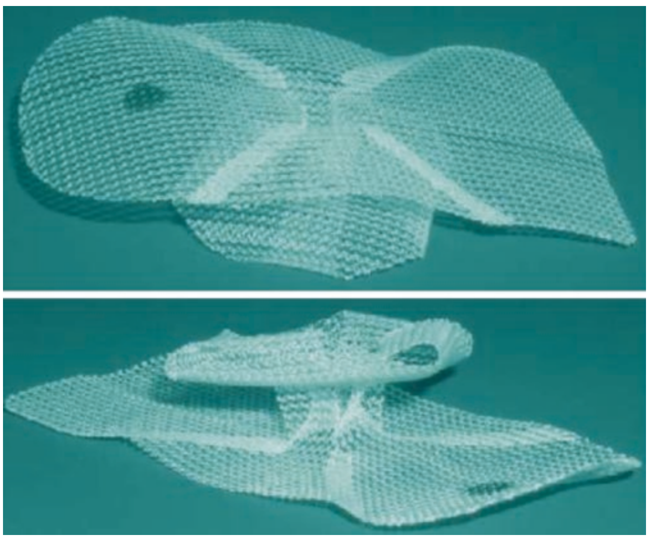

Fig. 7.162 PB inguinal implant

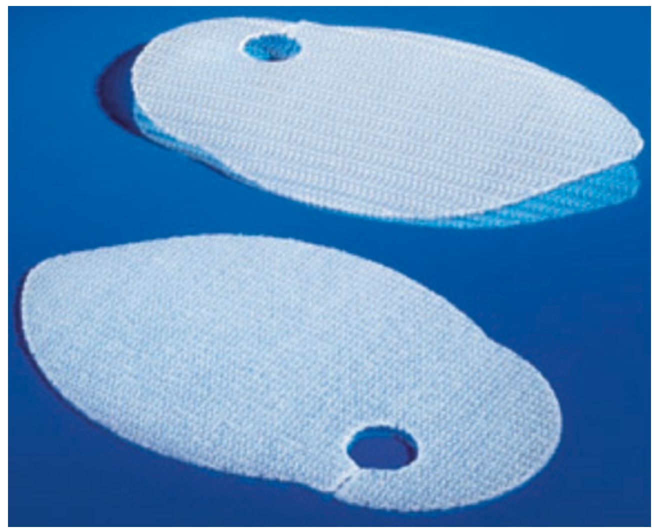

Fig. 7.164 T5 mesh

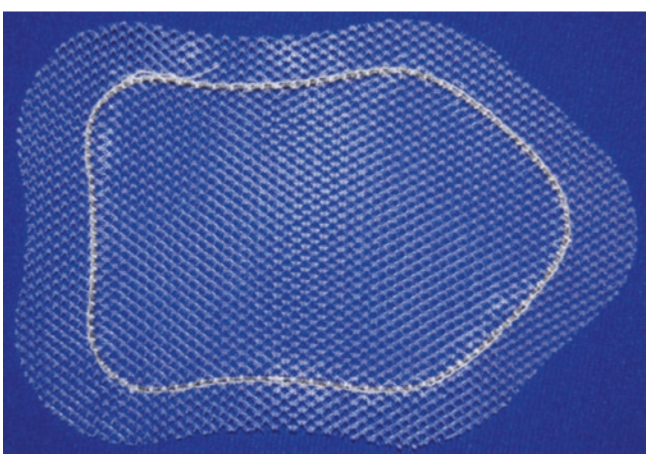

Fig. 7.163 Rebound HRB shield

and sizes (medium, large, and extra large). They differ in the weight of the PP within each product. The former is of the heavy weight Bard mesh and the latter is of the lighter Bard Soft Mesh. It is quite apparent in the figure that the lower product is the lighter one (Fig. 7.166). Both have an "M" and an arrow on the medial aspect of the product to indicate the positioning of the prosthesis. These are curved to conform to the shape of the pelvis. Because of this curved shape, there is a right and left product. There is also an indentation on the inferior aspect of the product to indicate the location of the iliac vessels. There is no required fixation with the heavier weight product in either the TAPP or TEP approaches.

The 4D Mesh product has been described above but they have manufactured a product for laparoscopic repair of these hernias (Fig. 7.167). It is of the same composition of the other product but is shaped for this technique. *CO3A* and *CO3+* are of similar material that has been previously described in other sections (Table 7.12) in the chapter (Fig. 7.83). They both are POL with impregnated PUR and have knitted grips to hold the products in place. These have been configured in many different shapes for laparoscopic inguinal and ventral hernia repair. *CO3+* is a flat sheet but *CO3A* is recommended for laparoscopic inguinal hernia repair due its specific configuration (Fig. 7.168).

C-QUR FX has a light coating of the Omega 3 fatty acid that the other C-QUR products possess (Fig. 7.169). *C-QUR CentriFX* is made in a laparoscopic shape (Fig. 7.170). *C-QUR CentriFX* is also part of the ProLite materials coated with O3FA but is shaped for use in either a left or right laparoscopic repair of inguinal hernias. It is one of the few products that can be interchanged in such a fashion. The only one of these materials that is partially absorbable is that of the *Easy Prothes Partially Absorbable 3D Mesh* (Fig. 7.171). It is made of the same material as the Easy Prothes Partially Absorbable Flat product PAS noted above (Fig. 7.115). The *JG inguinal* implant also has an anatomic shape that includes a raised edge for the cord structures (Fig. 7.172). There is a round black mark to indicate the inferior internal edge, as there is a left and right product. This is available in a standard or lightweight version.

Table 7.19 Pre-shaped products for laparoscopic inguinal hernia repair

3D Anatomic, Microval, Saint-Just-Malmont, France
3D Max, Davol, Inc., Warwick, RI, USA
3D Max Light, Davol, Inc., Warwick, RI, USA
4D Laparoscopic Mesh, Cousin Biotech, Wervicq-Sud, France
CLAP, Di.pro Medical Devices, Torino, Italy
*CO3A,*THT Bio-Science, Montpelier, France
*CO3+,*THT Bio-Science, Montpelier, France
C-QUR FX, Getinge Group, Wayne, NJ
C-QUR CentriFX, Getinge Group, Wayne, NJ
Easy Prothes Partially Absorbable 3D Mesh, TransEasy Medical Tech.Co.Ltd, Beijing, China
JG Inguinal, Microval, Saint-Just-Malmont, France
Parietex ProGrip Anatomical, Medtronic, Minneapolis, MN, USA
Parietex Anatomical Mesh, Medtronic, Minneapolis, MN, USA
Parietex Anatomical Mesh with Suture, Medtronic, Minneapolis, MN, USA
Parietex Folding Mesh with Suture, Medtronic, Minneapolis, MN, USA
PS, Microval, Saint-Just-Malmont, France
Premium, Cousin Biotech, Wervicq-Sud, France
SMA, THT Bio-Science, Montpelier, France
SM2+, THT Bio-Science, Montpelier, France
SMH2+, THT Bio-Science, Montpelier, France
SMH2A, THT Bio-Science, Montpelier, France
SM3, THT Bio-Science, Montpelier, France
SM3+, THT Bio-Science, Montpelier, France
SurgiMesh WN, Aspide Medical, St. Etienne, France
Visilex, Davol, Inc., Warwick, RI, USA

Parietex Lap ProGrip Anatomic is POL with microgrips that has been described above but it is configured as either the left or right for laparoscopic repair specifically (Fig. 7.173). *Parietex Anatomical Mesh* is of the same three-dimensional weave of POL as the other Parietex products on the lower portion of the product making if softer and is designed to lie on the iliac vessels (Fig. 7.174). Its shape is similar to the ProGrip Anatomic but it does not have the microgrips. The portion that is placed on the posterior aspect of the inguinal floor is a more rigid two-dimensional weave to aid in handling. It is generally used with the application of some type of fixation but some surgeons do not see the need to add these fasteners. It has a left and right design. It is available with an embedded suture to ease insertion and an included flap to place the cord structures (Fig. 7.175). The *Folding Mesh with Suture* is shaped as a flat polyester mesh with rounded edges (Fig. 7.176). To aid in the insertion and deployment of this mesh in the preperitoneal space during the laparoscopic repair there is a suture that is woven through the material. This suture is placed such that when it is pulled tight the mesh will be drawn into a small somewhat cylindrical shape. It is then placed into the preperitoneal space whereupon the suture is cut, allowing the mesh to resume its original shape. It can then be positioned appropriately. This device is also available with a slit if one desires to place the cord structures within the slit.

PS implant is a nonwoven PP material that is rather ovoid in shape (Fig. 7.177). It can be used in the repair of either the left or right inguinal hernia. It can be used with or without

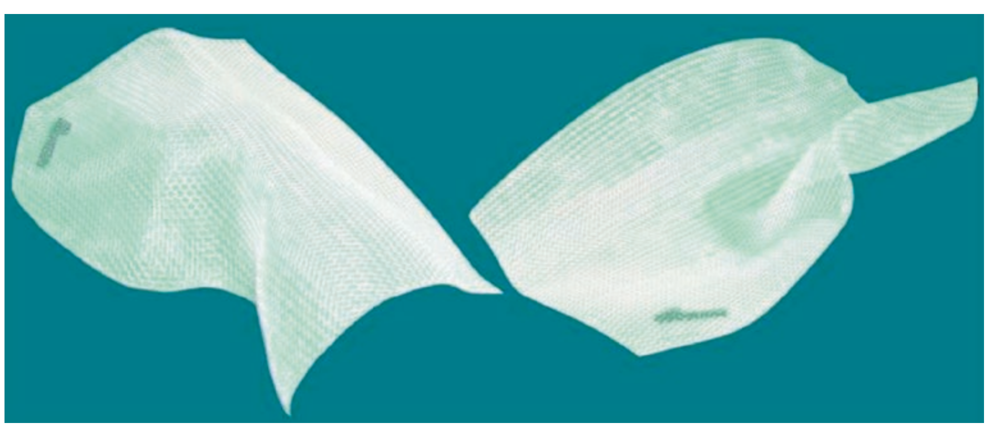

Fig. 7.165 3D anatomic

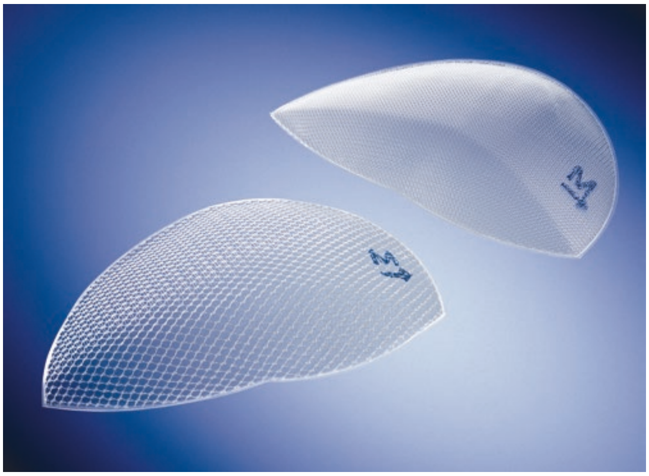

Fig. 7.166 3D Max regular (right) and light (left)

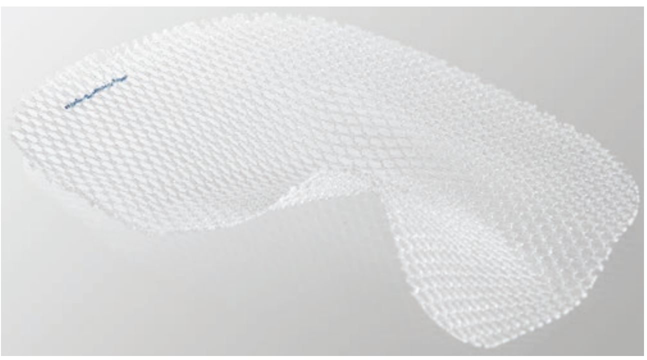

Fig. 7.167 4D laparoscopic

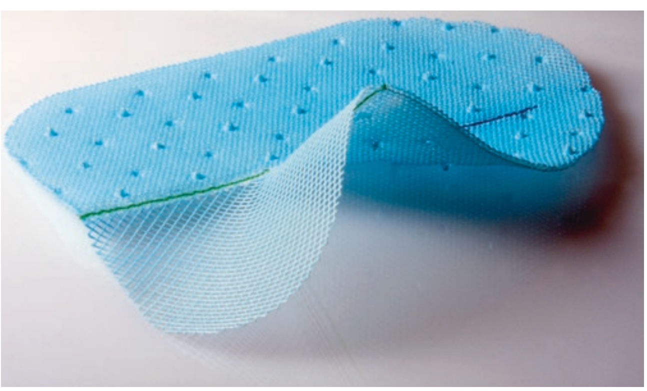

Fig. 7.168 CO3A

fixation. *Premium* mesh has also been described above for open inguinal but it is available in various shapes for the laparoscopic repair (Fig. 7.178). There is a blue polypropylene suture to mark the medial side of the product. *SMA* and *SMH2* products are similar products. They are both anatomi

Fig. 7.169 C-Qur FX

Fig. 7.170 C-Qur CentriFX

cally shaped but the *SMA* is made of polyester and impregnated PUR (Fig. 7.179). It is preferably used in the TEP repair. *SM2+* has previously been described in the flat mesh device section above. It is polyester and impregnated PUR and shaped for this repair (Fig. 7.180). *SMH2+* is a product that has a shape similar to the 3D Max and the Easy Prosthes 3D Mesh (Fig. 7.181). It differs in that it is a combination product of permanent material, PP, and impregnated polyurethane (PUR). *SMH2A* is also made of PP and PUR but

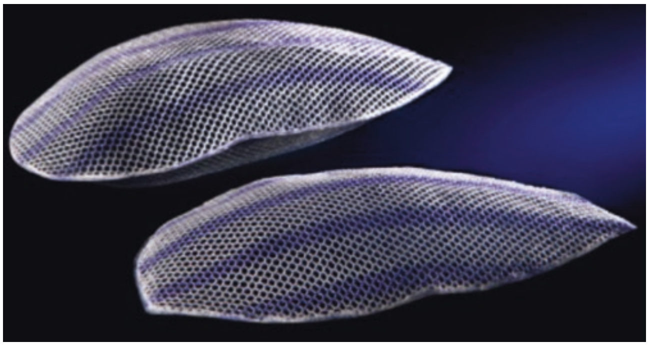

Fig. 7.171 Easy prothes 3D

Fig. 7.172 JG inguinal

Fig. 7.173 Lap ProGrip anatomic (All rights reserved. Used with Permission of Medtronic)

like the *SMA*, it should be used preferably in the TEP approach to inguinal hernia repair due to its shape (Fig. 7.182). *SM3* and *SM3+* have been described in the flat mesh section above (Figs. 7.88 and 7.89). They are configured for use in the laparoscopic repair of inguinal hernias.

SurgiMesh WN has the same structure as that of most of the SurgiMesh products listed in the prior tables (Fig. 7.67).

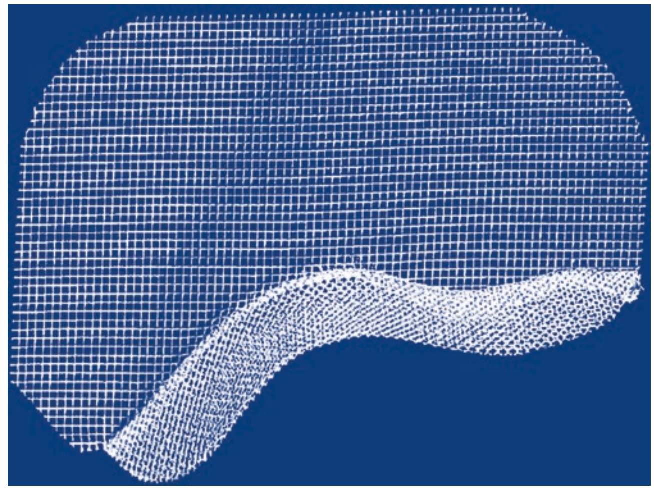

Fig. 7.174 Parietex anatomic (All rights reserved. Used with Permission of Medtronic)

Fig. 7.175 Parietex anatomic with suture (All rights reserved. Used with Permission of Medtronic)

There are two laparoscopic products. One is a single flat square sheet with a rounded portion cutout on one corner. This is to be placed at Cooper's ligament. The other product has a keyhole and a flap to allow the product to be placed onto the posterior wall of the inguinal canal with the cord structures placed in the keyhole. The flap then covers the slit and keyhole to seal this defect in the mesh. *Visilex* is flat Bard mesh that has a stiffer border designed to ease the manipulation of the product in the preperitoneal space (Fig. 7.183).

Prostheses for Incisional and Ventral Hernioplasty with an Absorbable Component

The original impetus behind the development of these products was the popularity of the laparoscopic methodology. In general, however, all of these prosthetic devices can or have been used in both open and laparoscopic

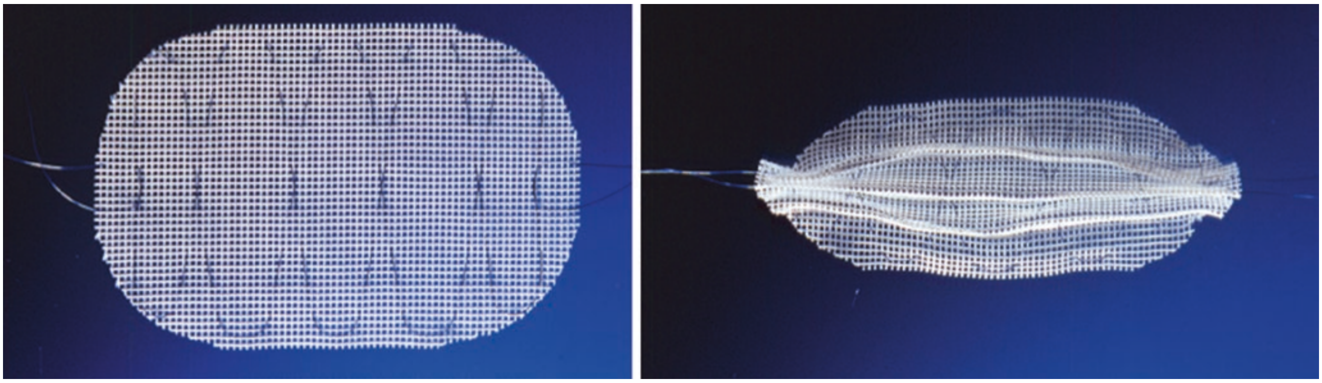

Fig. 7.176 Folding mesh with suture ()

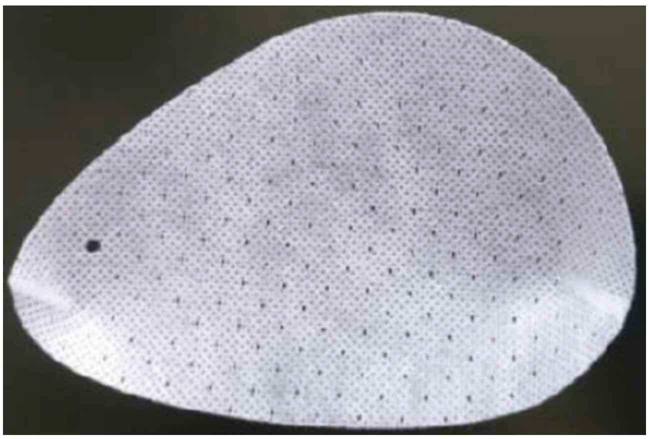

Fig. 7.177 PS

Fig. 7.178 Premium laparoscopic

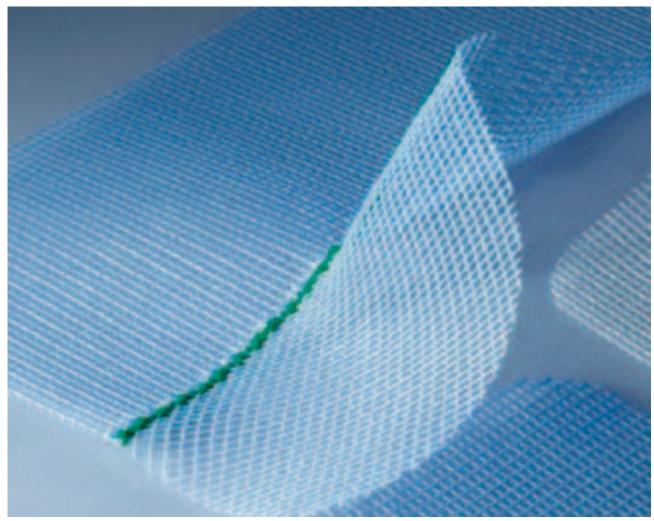

Fig. 7.179 SMA

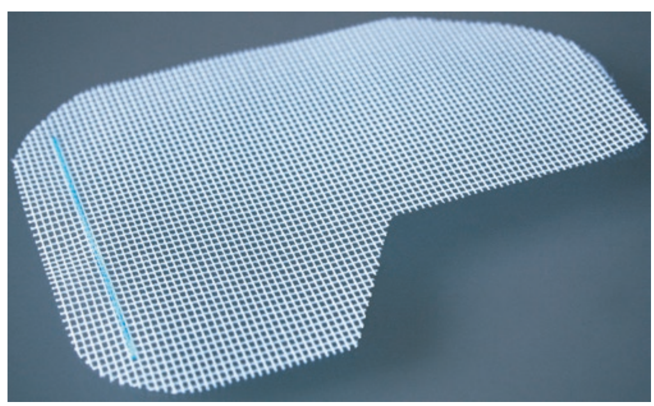

Fig. 7.180 SM2+

incisional hernioplasties. All of these have the common purpose to repair the hernia and prevent the development of adhesions with the attendant complications associated with this result of the healing processes. These are generally referred to as "tissue-separating" meshes as they create an absorbable barrier between the permanent product and the viscera (Table 7.20). They are available in a variety of shapes and sizes, which are too many to enumerate here. The reader is referred to the individual company for further information.

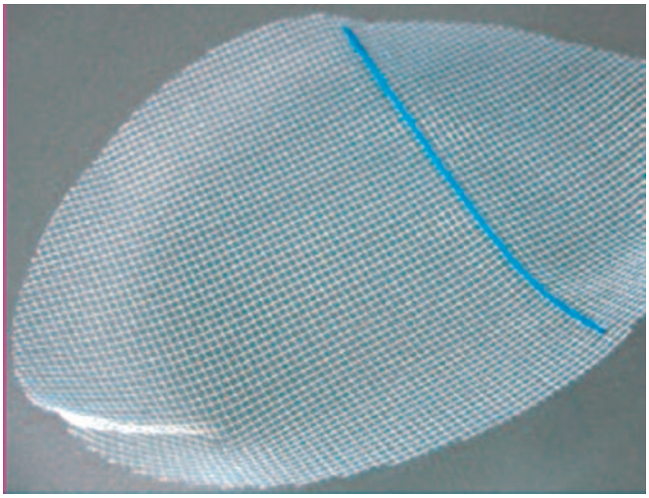

Fig. 7.181 SMH2+

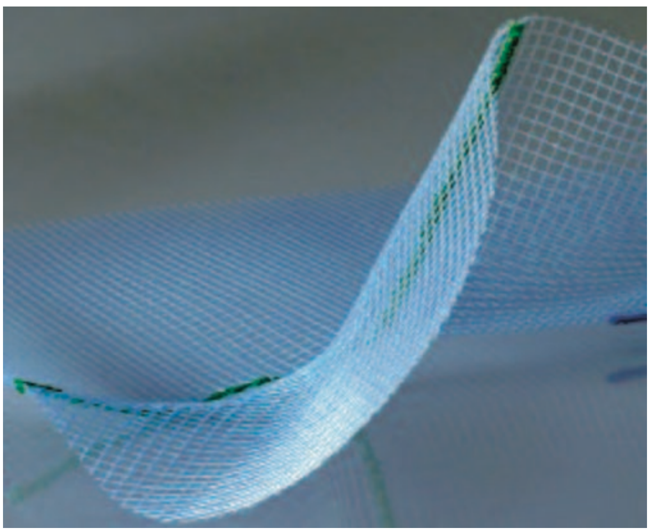

Fig. 7.182 SMH2A

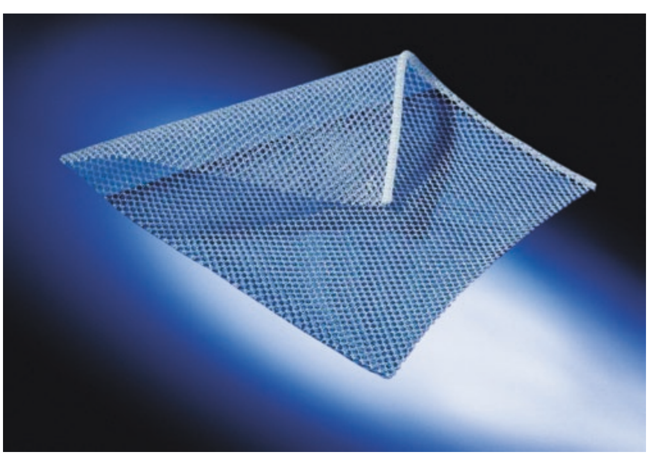

Fig. 7.183 Visilex

Table 7.20 Prostheses with an absorbable component

Adhesix, Davol, Inc., Warwick, RI, USA
CA.*B.S.'air SR*, Cousin Biotech, Wervicq-Sud, France
C-QUR FX, Getinge Group, Wayne, NJ, USA
C-QUR Mosiac, Getinge Group, Wayne, NJ, USA
C-QUR TacShield, Getinge Group, Wayne, NJ USA
C-QUR V-Patch, Getinge Group, Wayne, NJ, USA
Easy Pro Composite Mesh, TransEasy Medical Tech.Co.Ltd, Beijing, China
Parietene Composite, Medtronic, Minneapolis, MN, USA
Parietex Composite Ventral Patch, Medtronic, Minneapolis, MN, USA
Parietex Optimized Composite (PCO_x*)*, Medtronic, Minneapolis, MN, USA
Parietex Optimized Composite (PCO_x*) Skirted Mesh*, Medtronic, Minneapolis, MN, USA
Parietene DS, Medtronic, Minneapolis, MN, USA
Parietene ProGrip, Medtronic, Minneapolis, MN, USA
Parietex ProGrip, Medtronic, Minneapolis, MN, USA
Physiomesh Open, Ethicon, Inc., Somerville, NJ, USA
Proceed, Ethicon, Inc., Somerville, NJ, USA
Proceed Ventral Patch, Ethicon, Inc., Somerville, NJ, USA
SepraMesh IP, Davol, Inc., Warwick, RI, USA
Symbotex, Medtronic, Minneapolis, MN, USA
Ventralight ST, Davol, Inc., Warwick, RI, USA
Ventralex ST, Davol, Inc., Warwick, RI, USA
Ventrio ST, Davol, Inc., Warwick, RI, USA

The resorption of that nonpermanent substance leaves a permanent layer of mesh that will incorporate into the tissues of the patient. The controversial part of this idea is the fact that the problems that are related to the development of adhesions following the implantation of a synthetic biomaterial do not become manifest for many years post-implantation. Therefore, the late effects of these products will necessitate many years of follow-up to validate these claims. At the present time, however, these meshes do seem to live up to their expectations. There have been some central failures due to materials that were too lightweight and/or macroporous. These generally are no longer available.

Adhesix is the same product that was listed in Table 7.16 (Fig. 7.113). It is touted that this can be used in the preperitoneal position, the retrorectus space or as an onlay but it is not designed for use in with contact with the viscera. CA.*B.S.'air SR* has a permanent component of 45% lightweight PP and 55% resorbable poly-L-lactic acid (PLLA) (Fig. 7.184, left). It differs from all of the other products in that it has two permanent sutures with needles that are attached and it is also accompanied by a balloon dissection device as is the CA.B.S.'Air described below. The attached sutures are ePTFE and polyester. This device is designed for use in umbilical and ventral hernia repair. The entire product is inserted; the balloon is used to dissect the tissues and is

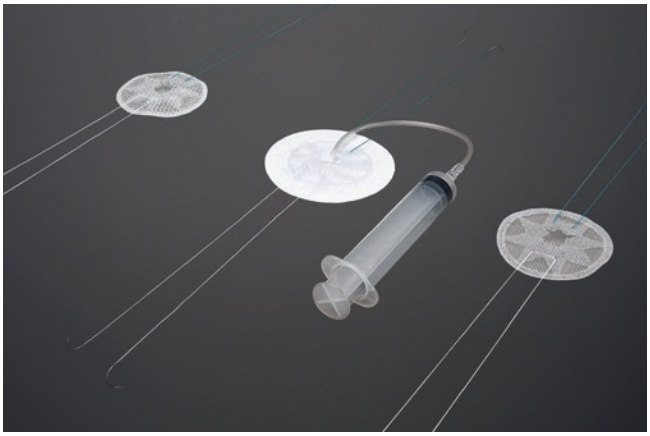

Fig. 7.184 CA.B.S.'air SR (left), CA.B.S.'air composite (middle), CA.B.S.'air light (right)

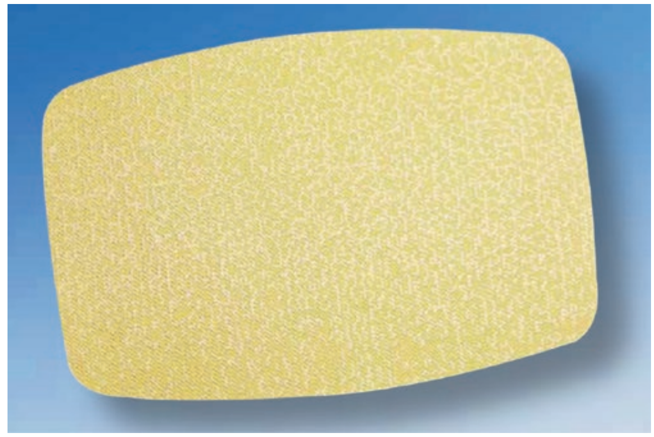

Fig. 7.185 C-Qur Mosaic

then removed leaving behind the prosthesis with the attached sutures to fixate it. The figure shows the balloon in only one of the products.

C-QUR Mosiac is made of a lightweight ProLite mesh onto which Omega-3 Fatty Acid (O3FA) has been coated onto the product (Fig. 7.185). These fatty acids are in a cross-linked gel that covers both sides of the material and impart a characteristic dark yellow color. O3FA will absorb over a period of 3–6 months. It is to be used when tissue-separating capabilities are required in the repair of hernias. *C-QUR FX* has a light spray of O3FA so that the product is to be used in the situations where tissue separation is not required (Fig. 7.169). As such it is also configured for use in open and laparoscopic inguinal hernia repair. *C-Qur TacShield* is designed for open repair of incisional and ventral hernias (Fig. 7.186). The apron on it is made to avoid contact of fixation devices to the intestine. The *C-QUR V-Patch* is designed for umbilical hernia repair and trocar site defects but one could see its use for smaller incisional hernias as well (Fig. 7.187). It combines the ProLite material such that there is one layer of the C-Qur FX and one layer of the C-Qur mesh itself that are sewn together around an O3FA coated mesh stabilizing ring. The fixation straps can be secured to the edge of the defect, if desired.

EasyPro Composite Mesh is constructed of lightweight PP with a barrier coating of poly-lactide-co-caprolactone (Fig. 7.188). It is usage. It has an "F" on the visceral surface to identify the orientation toward the intestine. It is also available in a precut size for complicated inguinal hernia repair.

Parietene Composite is PP coated with the hydrophilic collagen and other substances that are used in the better-known Parietex Composite discussed below. *Parietex Composite Ventral Patch* is designed for the smaller defects in the abdominal wall such as umbilical or epigastric hernias (Fig. 7.189). It is supplied with a deployment system that

Fig. 7.186 C-Qur TacShield

Fig. 7.187 C-Qur V-Patch

Fig. 7.188 EasyPro composite mesh

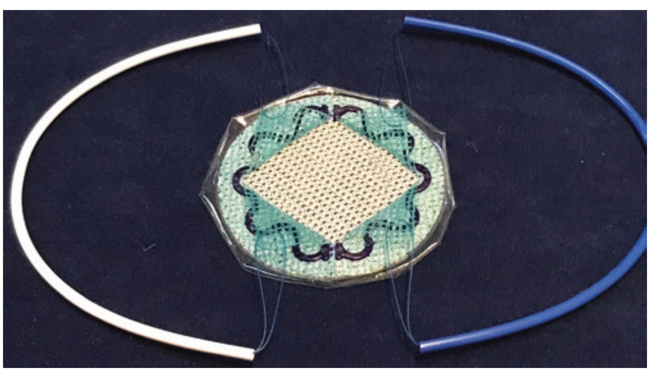

Fig. 7.189 Parietex composite ventral patch (All rights reserved. Used with Permission of Medtronic)

Fig. 7.190 Parietex composite optimized (All rights reserved. Used with Permission of Medtronic)

Fig. 7.191 AccuMesh positioning system (All rights reserved. Used with Permission of Medtronic)

Fig. 7.192 Parietex optimized skirted mesh (All rights reserved. Used with Permission of Medtronic)

consists of a PGLA structure that is implanted and two nylon suture "positioning" arms that are removed after it is secured in place. It has an incorporated hydrophilic layer of a mixture of oxidized Type I atelocollagen, polyethylene glycol, and glycerol, which is absorbable. *Parietex Optimized Composite* is the same POL biomaterial that is described earlier in this chapter (Fig. 7.190). It is supplied with or without preplaced sutures. It can be purchased with the *AccuMesh Positioning System* (Fig. 7.191). It is also available for open repair as *Parietex Optimized Composite Skirted Mesh* (Fig. 7.192). The skirt is a second layer placed over the larger mesh itself to allow for easier placement of the fixation devices that can be used to fix the product to the anterior abdominal wall in the open technique. *Parietene DS* should be available at the time of publication. It is a dual sided product that has Parietene macroporous PP that is coated on one side with glycolide, caprolactone, trimethylene carbonate, and lactose. *Parietene ProGrip* and *Parietex ProGrip* also differ in that the former is of PP and the latter is of POL (Fig. 7.114). Both have the polylactic acid grippers (described earlier in this chapter) so that they do not need fixation potentially. The coating on these products is very minimal so it is not recommended that these products should contact the viscera.

Physiomesh Open is a skirted product (Fig. 7.193). It is a macroporous mesh of knitted polydioxanone (PDO) and PP fibers that is then laminated to absorbable poliglecaprone-25 film. There is a larger PDO fiber that is sewn into the center of the long axis of the product as an orientation marker. It is designed for open not laparoscopic use and cannot be trimmed or cut. *Proceed* is composed of an oxidized regenerated cellulose (ORC) fabric and Prolene Soft Mesh which is encapsulated by a polydioxanone polymer that holds this together (Fig. 7.194). The fabric acts as a barrier to separate the PP from the tissue. The ORC is absorbed within 4 weeks.

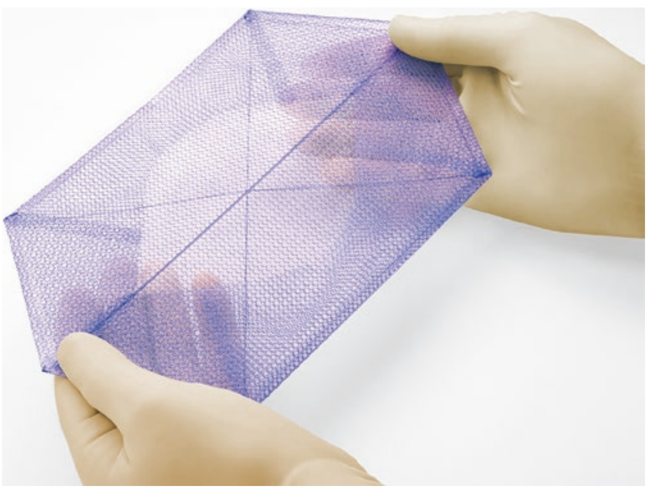

Fig. 7.193 PHYSIOMESH open (Image courtesy of Ethicon, Inc.)

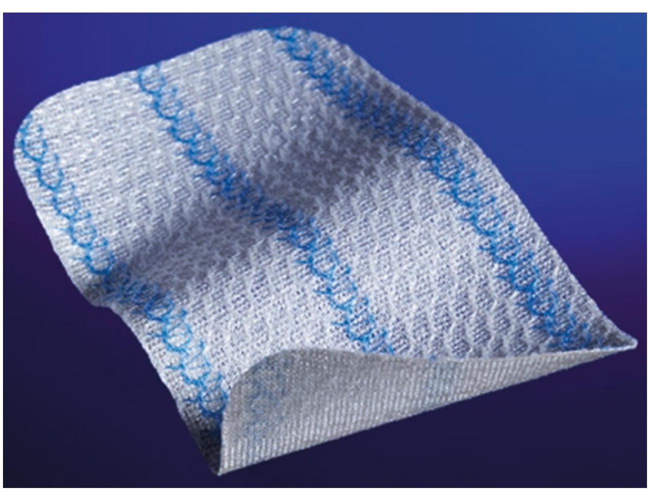

Fig. 7.194 Proceed (Image courtesy of Ethicon, Inc.)

It should be noted that the instructions for use state "Proceed Mesh has an ORC component that should not be used in the presence of uncontrolled and/or active bleeding as fibrinous exudates may increase the chance of adhesion formation." The *Proceed Ventral Patch (PVP)* is another version that also has an ORC layer that is placed toward the intestine (Fig. 7.195). In this product, there is an additional layer of polydioxanone polymer and a positioning ring to provide memory. Vicryl mesh (polyglactin 910) is placed on top of the polydioxanone and is encapsulated with a polydioxanone film. The sutures that are seen in the photo are of polyester.

SepraMesh IP is a single layer of polypropylene and is covered by barrier that is a combination of carboxymethylcellulose and hyaluronic acid (Fig. 7.196). It is bound together with polyglycolic acid fibers and a hydrogel. This product requires brief immersion into saline solution prior to its use to activate the gel. This hydrogel swells following implantation to cover the fixation devices that are used. This portion of the product is stated to last approximately 4 weeks, at which point, it has been resorbed. There is a lighter weight version that is *Ventralight ST* (Fig. 7.197). The "Sepra" technology has been extended to the original Ventralex and Ventrio products (Table 7.21). The ePTFE surface has been replaced with the tissue-separating material that is used on the SepraMesh IP and Ventralight ST prostheses. These products are called *Ventralex ST* and *Ventrio ST* (Figs. 7.198

Fig. 7.195 Proceed ventral patch (Image courtesy of Ethicon, Inc.)

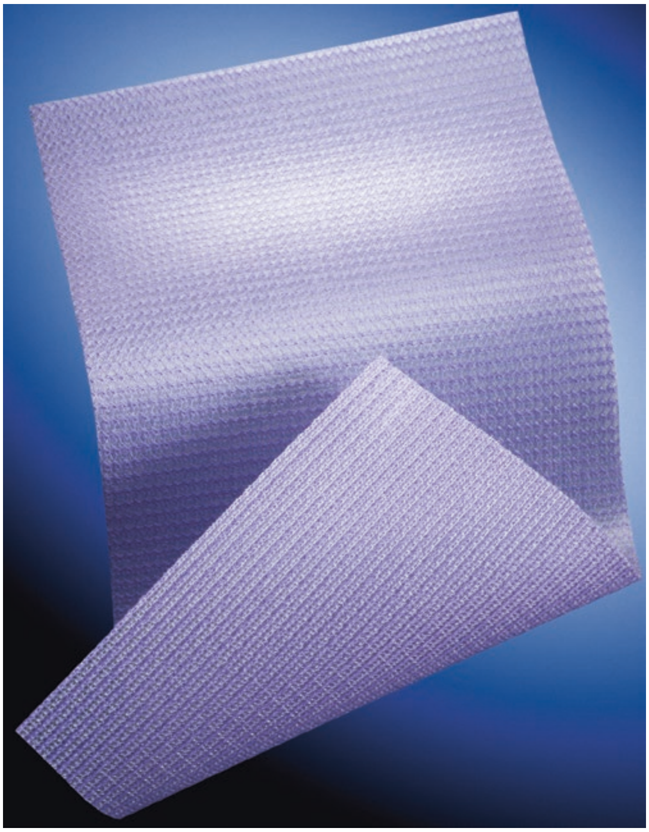

Fig. 7.196 SepraMesh IP

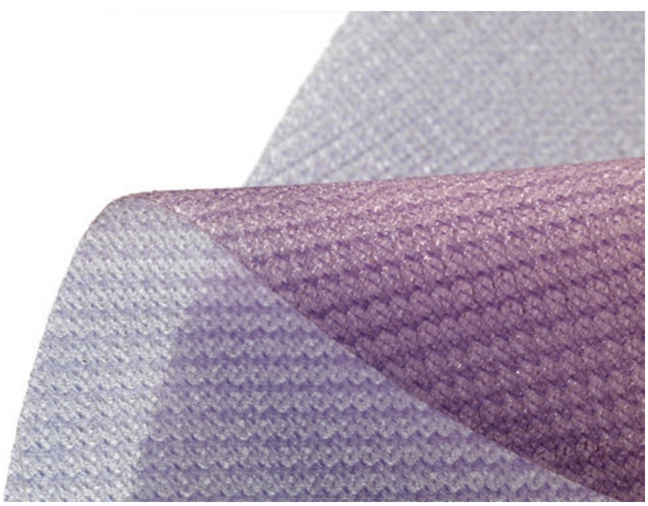

Fig. 7.197 Ventralight ST

Fig. 7.198 Ventralex ST

Fig. 7.199 Ventrio ST

and 7.199). *Symbotex* is a polyester material that is lighter in weight than the Parietex PCO (Fig. 7.200). It has the same barrier material as the PCO product described above (i.e., Type I atelocollagen, polyethylene glycol and glycerol). The green marker is 2D polyester. It is also available with a skirted design to facilitate open repair (Fig. 7.201).

Combination Permanent Materials for Incisional and Ventral Hernioplasty

These products are a combination of a single product that is manufactured in two different forms or, more commonly, a combination of two different products (Table 7.21). The method of fixation of these products differs from each manufacturer. There are some that have been described earlier in this chapter that are single products (ePTFE, cPTFE, or PVDF) and are not described again here (Tables 7.13 and 7.14). What is consistent

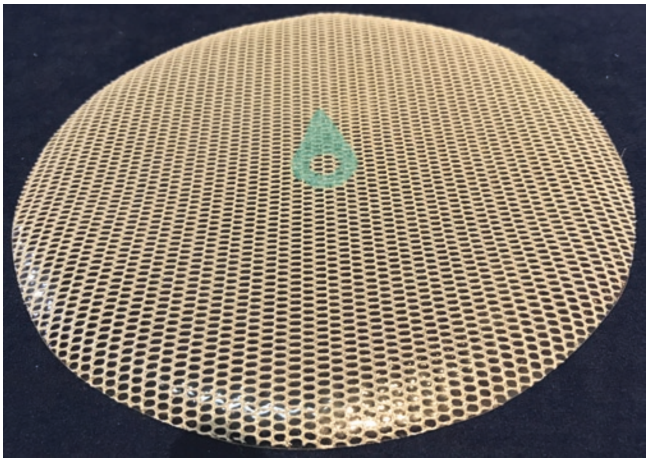

Fig. 7.200 Symbotex (All rights reserved. Used with Permission of Medtronic)

Fig. 7.201 Symbotex skirted mesh (All rights reserved. Used with Permission of Medtronic)

Table 7.21 Ventral hernia products entirely of permanent material

CA.*B.S 'air Composite*, Cousin Biotech, Wervicq-Sud, France
CA.*B.S 'air Light*, Cousin Biotech, Wervicq-Sud, France
ClearMesh Composite (CMC), Di.pro Medical Devices, Torino, Italy
CO3+, THT-Bio-Science, Montpelier, France
Combi Mesh Plus, Angiologica, S. Martino Sicc., Italy
Composix E/X Mesh, Davol, Inc., Warwick, RI, USA
Composix L/P Mesh, Davol, Inc., Warwick, RI, USA
Composix L/P Mesh with ECHO PS, Davol, Inc., Warwick, RI, USA
DualMesh, W. L. Gore & Associates, Elkhart, DE, USA
DualMesh Plus, W. L. Gore &Associates, Elkhart, DE, USA
DualMesh Plus with Holes, W. L. Gore &Associates, Elkhart, DE, USA
Dulex, Davol, Inc., Warwick, RI, USA
DynaMesh IPOM, FEG Textiltechnik mbH, Aachen, Germany
Intra, Microval, Saint-Just-Malmont, France
IntraMesh T1, Cousin Biotech, Wervicq-Sud, France
IS 180, THT Bio-Science, Montpelier, France
Omyra Mesh, B. Braun Melsungen AG, Melsungen, Germany
MotifMESH, Proxy Biomedical Ltd, Galway, Ireland
MycroMesh, W. L. Gore &Associates, Elkhart, DE, USA
MycroMesh Plus, W. L. Gore &Associates, Elkhart, DE, USA
Prefix, THT Bio-Science, Montpelier, France
Plurimesh (PCMC), Di.pro Medical Devices, Torino, Italy
Rebound HRD V, ARB Medical, Minneapolis, MN, USA
Relimesh, HerniaMesh, Torino, Italy
SMH2+, THT Bio-science, Montpelier, France
SM3+, THT Bio-Science, Montpelier, France
Soft Tissue Patch, W. L. Gore &Associates, Elkhart, DE, USA
SurgiMesh XB, Aspide Medical, St. Etienne, France
TiMesh, GfE Medizintechnik, Nuremburg, Germany
TiO_2 Mesh, Bayreuth, Germany
Umbilical—CMC, Di.pro Medical Devices, Torino, Italy
Ventralex, Davol, Inc., Warwick, RI, USA
Ventrio Hernia Patch, Davol, Inc., Warwick, RI, USA
Ventrio-S, THT Bio-Science, Montpelier, France

in all of the prostheses is the creation of some type of a barrier to adhesion formation while allowing for ingrowth on the parietal side of these meshes to repair a hernia effectively.

The CA.*B.S. 'air Composite* is similar to the *CA.B.S.' air SR* (Fig. 7.184, left) device described above. They both are constructed of two materials and inserted with the aid of a balloon dissection device that is removed (Fig. 7.184, middle). The SR device is semi-resorbable while the CA.B.S.'air is totally made of permanent material. These materials are PP on the parietal surface and ePTFE on the visceral surface. It is the only one of these CA.B.S.' air products that can be used in the intraperitoneal position. The CA.*B.S.' air Light* is similar to the SR but there is no absorbable component and it is pure polypropylene (Fig. 7.184, right). *CO3+* has been described in the flat mesh section (Fig. 7.83). It is a combination of POL and PUR with grips.

ClearMesh Composite (CMC) is a pure PP mesh (Fig. 7.202). There is a textured side that is composed of a single filament macroporous weave and a non-adhesive side that is composed of a non-porous smooth PP film. It is for use in the intraperitoneal space. It is further designated as *CMC 2P*, which is elliptical in shape and the *CMC 2P–C,* which is round. *Plurimesh (PCMC)* is a similar concept as the CMC except that it is designed for incisional or parastomal hernia repair (Fig. 7.203). It has sewn seams that can be used to cut the mesh to conform to the needs of the hernia treated. The CMC product line also includes an umbilical version. *Umbilical CMC* is round and includes blue stitching and tethers to aid in positioning (Fig. 7.204). *Combi Mesh Plus* is a combination of PP and polyurethane to allow usage intrabdominally (Fig. 7.205). There is an attached suture to delineate the parietal surface. The polyurethane layer faces the viscera.

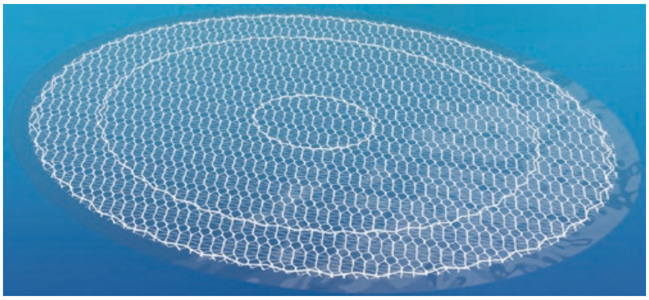

Fig. 7.202 ClearMesh composite (CMC)

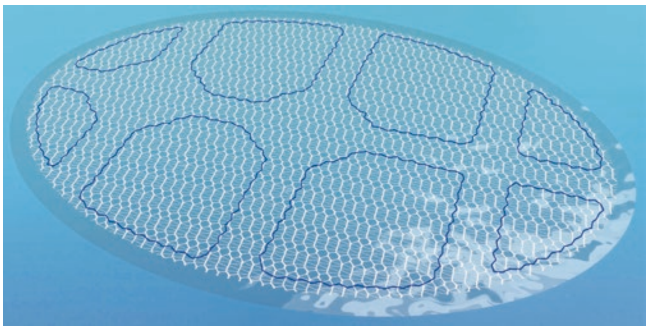

Fig. 7.203 Plurimesh (PCMC)

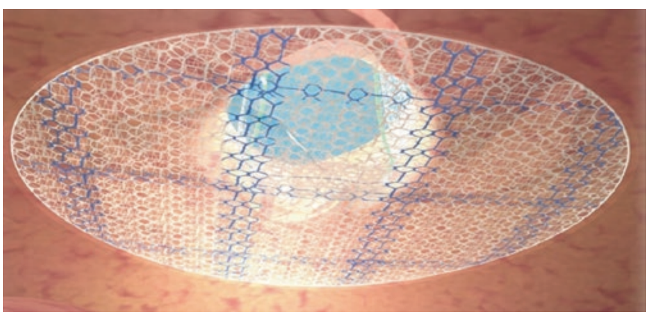

Fig. 7.204 Umbilical CMC

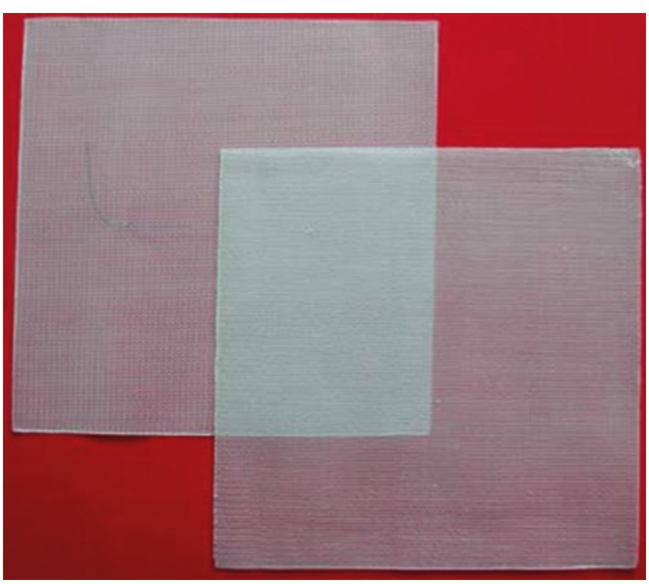

Fig. 7.205 Combi Mesh Plus

Composix E/X Mesh is flat Bard mesh on one side and ePTFE on the other side (Fig. 7.206). The edge of the perimeter of the elliptically shaped product is sealed to prevent contact of viscera to the PP. It is a low profile mesh. *Composix L/P* is very similar to the Composix E/X except that the former uses the lighter Bard Soft of silicon (Fig. 7.207). It is specifically designed for laparoscopic usage and can be used with a supplied introduction tool. The two mesh layers are sutured together with ePTFE suture. The Composix L/P is also available with the ECHO PS (Fig. 7.208). The green balloon shown in the figure will be inflated to firm up the mesh to allow for accurate positioning and fixation. There is an attached blue tubing on the opposite side that is not seen in the figure that is pulled through the abdominal wall to center the mesh. It is then cut and attached to a syringe that is used to inflate the balloon. Once fixation is completed, the balloon is deflated and removed. There is a newer version, ECHO2 PS, that has a nitinol core rather than the balloon.

DynaMesh IPOM is a similar PP weave as the DynaMesh described earlier in this chapter but it is slightly lighter than the latter product (Fig. 7.209). This version is intertwined with polyvinylidene fluoride (PVDF), which is also a monofilament. Because of this PVDF tissue-separating component it can be placed onto the viscera. The suture noted in the figure signifies which side should be placed against the abdominal wall as it is impossible to be certain with the naked eye which side should go up. *Intra* mesh is a combination of nonwoven PP on one side with a layer of silicone on the other as a tissue separating material (Fig. 7.210). It is one of the few materials available with this silicone barrier. This side is marked with a cross and “intra side” in black silicone ink. *IntraMesh T1* is similar to the Composix product line in that it is composed of one layer of PP and a second layer of ePTFE (Fig. 7.211). It is the only material that possesses lines on the product to delineate the midportions of each side to ease positioning for the laparoscopic approach. Cousin Biotech also sells a “mesh roller” which is a device to aid in the rolling of these materials to ease insertion via a trocar. *IS 180* is part of the intra-swing composite family, which is a macroperforated three-dimensional POL that has a coating of PUR on one surface. The latter is the tissue-separating component (Fig. 7.212). It is configured in a variety of shapes with or without PP sutures to aid in fixation. The company also has an available *Easy-Catch EC* device to be used for laparoscopic introduction of the material into the abdominal cavity. *Prefix* is similar in concept to the IS 180 but, as shown in the photo, there are preplaced sutures to allow for positioning of the product (Fig. 7.213). It is one of the few products that include pre-attached sutures with straight needles on them.

Rebound HRD V has previously been described in miscellaneous flat mesh section above (Fig. 7.101). It is designed for use in the preperitoneal space. *Relimesh* is another product that incorporates the PP on one surface and

Fig. 7.206 Composix E/X

Fig. 7.207 Composix L/P

Fig. 7.208 Composix L/P with ECHO PS

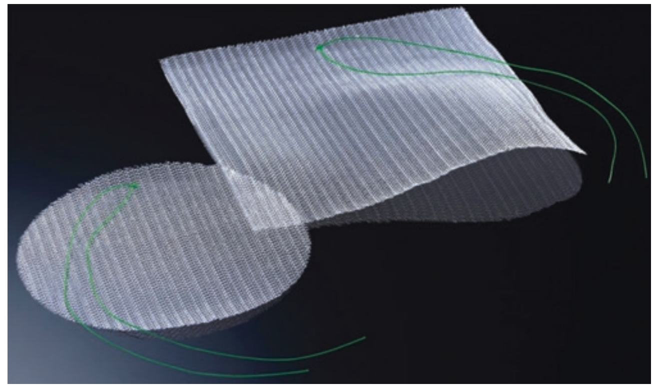

Fig. 7.209 DynaMesh IPOM

Fig. 7.210 Intra

Fig. 7.211 IntraMesh T1

ePTFE on the other to allow placement against the viscera (Fig. 7.214). It is a lighter weight product compared to other HerniaMesh products. Because of this, it can be rolled for insertion via a trocar. It is marked to aid in positioning and fixation. *SMH2+* has been previously described in the preformed inguinal hernia mesh section and is PP and PUR. It is also indicated for ventral hernias as well (Fig. 7.181). *SM3+* has been described in the flat mesh section of the chapter and has also been noted in other sections (Fig. 7.89). It is made of polyester and impregnated polyurethane and can be used in open or laparoscopic methods.

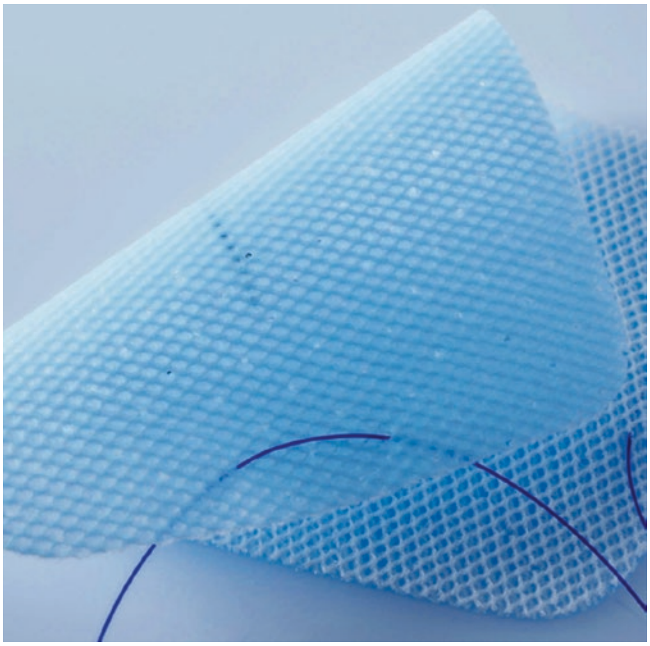

Fig. 7.212 IS 180

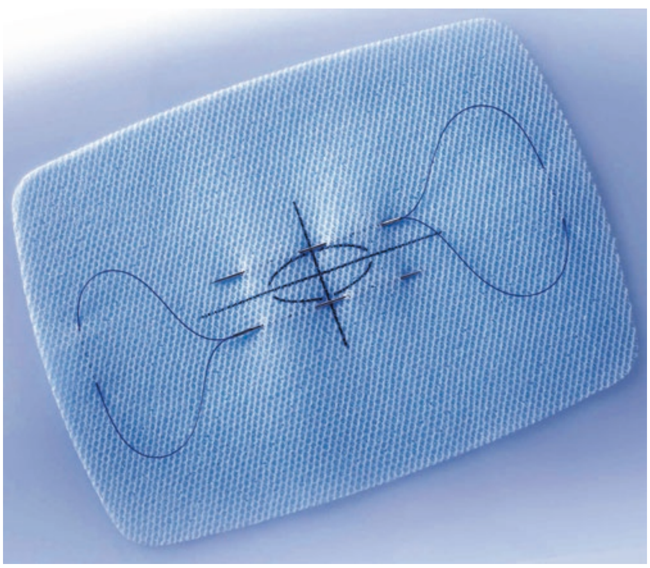

Fig. 7.213 Prefix

SurgiMesh XB has a non-woven, non-knitted structure as does the SurgiMesh WN described earlier (Fig. 7.215). It has an additional layer of silicone to allow contact with the viscera and is microperforated. This product is available in different shapes. There is a circular one that has an attached suture as a positioning aid (Tintra C). There is also a circular and an oval one with a skirt for fixation during open repair (Tintra CK or OK). *TiMesh* is the same material that has been described in several locations within this chapter (Fig. 7.120). The titanized PPM can be used in the intraperitoneal location (per the manufacturer). Another

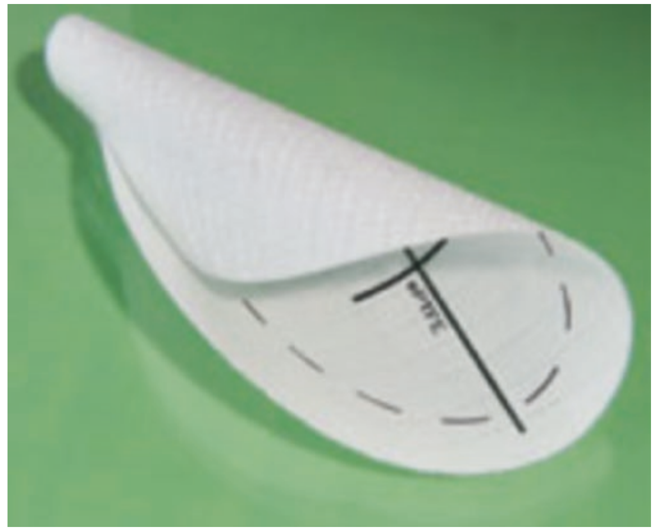

Fig. 7.214 Relimesh

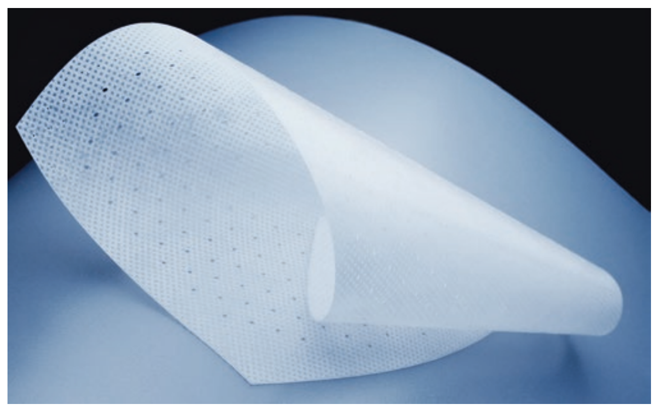

Fig. 7.215 SurgiMesh XB

titanized PPM is that of *TiO_2 Mesh* (Fig. 7.102). This is described in the Miscellaneous Flat Mesh section above.

Ventralex is a self-expanding PP device (because of the outer ring of polydioxanone) that has ePTFE on one side to allow placement adjacent to viscera (Fig. 7.216). It is round but smaller than the larger products such as the Composix products described above. It is intended for use in the smaller defects of the abdominal wall such as trocar or umbilical hernias. There is a pocket to allow for a finger to be inserted for placement. Two long straps are attached that can be used for fixation to the fascia. They are very long as this product can be inserted through a laparoscopic trocar to aid in the prevention of trocar hernias. The *Ventrio Hernia Patch* is comprised of two layers of PP that are stitched to an ePTFE layer as the tissue-separating component (Fig. 7.217). Within the PP surface there are “tubes” that house the absorbable polydioxanone (PDO) monofilament rings to give the mesh rigidity to aid in positioning and fixation. The purple PDO ring is absorbed within 6–8 months. *Ventro-S*

Fig. 7.216 Ventralex

Fig. 7.217 Ventrio hernia patch

Fig. 7.218 Ventro-S

is a member of the intra-swing family. It has the three-dimensional POL that is coated with PUR but has an additional skirt of two-dimensional POL impregnated with PUR (Fig. 7.218). As is common to the skirted meshes, it is to be used in open surgery.

Stomal Hernia Prevention and Repair Products

Table 7.22 Stomal prostheses

Colostomy Mesh, HerniaMesh, Torino, Italy
DynaMesh-IPST, FEG Textiltechnik mbH, Aachen, Germany
Parietex Composite Parastomal Mesh, Medtronic, Minneapolis, MN
Polyvalent Clear Mesh Composite (PCMC), Di.pro Medical Devices, Torino, Italy
TiLENE Guard, GfE Medizintechnik, Nuremburg, Germany

The development of a hernia wherever a stoma is created has been the challenge in the life of all patients with some type of an ostomy. Traditionally, relocation or primary closure was used to repair these hernias. It is now recognized that this is fraught with failure in most cases. Consequently, the use of a prosthetic material has become nearly standard to repair these hernias. In fact, recent trends indicate that the use of a mesh of some type when the stoma is created may be the preferred option. Prevention has become the new effort in mesh construction (Table 7.22). Many of these involve the use of one of the biologic, synthetic absorbable or permanent products described earlier in this chapter. As with many of the other products in this chapter, these can generally be used with the open or laparoscopic technique.

Colostomy Mesh is a single layer PP product (Fig. 7.219). It has a five-centimeter hole in the center of the material through which the intestine can be placed during stomal creation. Of course, the mesh can be cut if this product is used to repair a parastomal hernia. It is available in a “rigid” and a “semi-rigid” construction.

DynaMesh-IPST, like its parent material, is made of both PVDF and PP (Fig. 7.220). It is preshaped and three-dimensional. *Parietex Composite Parastomal Mesh* is of the same material as that described previously. This is supplied in two sizes and is available with a hole or without a hole and a central band (Figs. 7.221 and 7.222). The available opening of the hole can either be 3.5 cm or 5.0 cm. *Plurimesh (PCMC)* has already been described for incisional and ventral hernia repair. It can also be used for parastomal hernia repair (Fig. 7.203). It is supplied in such a manner that it can be cut to confirm to whatever the size the surgeon chooses.

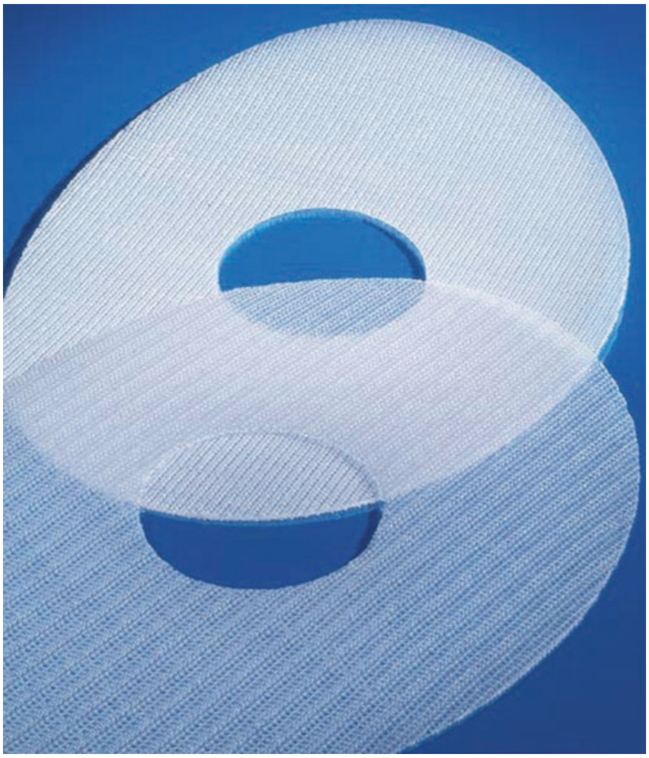

Fig. 7.219 Colostomy mesh

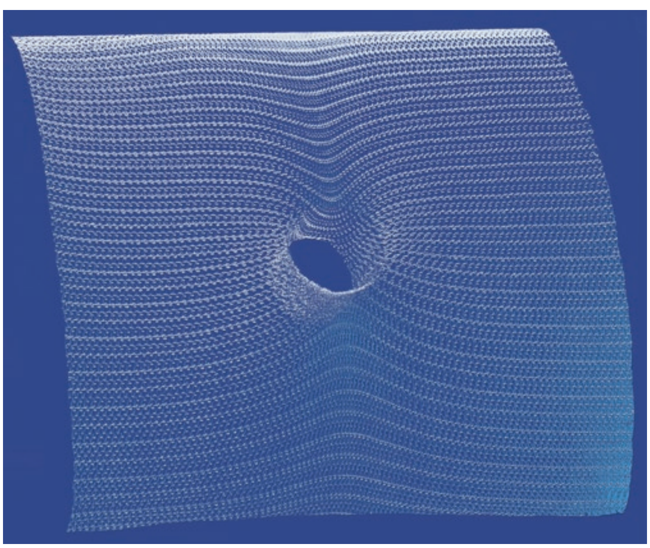

Fig. 7.220 DynaMesh-IPST

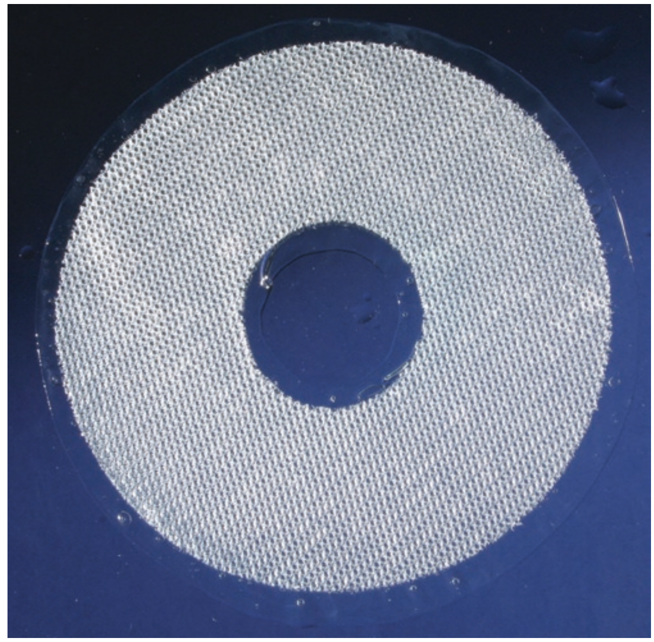

Fig. 7.221 Parietex parastomal with hole (All rights reserved. Used with Permission of Medtronic)

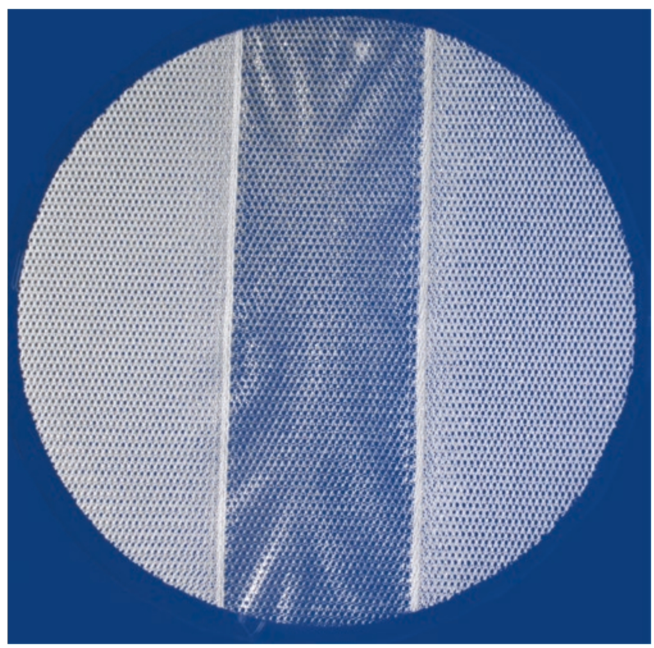

Fig. 7.222 Parietex parastomal without hole (All rights reserved. Used with Permission of Medtronic)

TiLENE Guard is of titanized PP (Fig. 7.223). It is supplied with a flap, which is closed after the intestine is placed through the central hole. It is supplied in the light and dual-weight (light and medium) meshes. There is a set, which contains *TiLENE* mesh that is to be applied as a "sandwich" technique to repair or prevent herniation through the stoma location.

Hiatal Hernia Repair Products

The use of permanent meshes to repair hiatal hernias has been commonplace for many years. The introduction of the biologic products has resulted in a decline in the application of the permanent products at this position. The real concern is of erosion of the product into the esophagus or infection

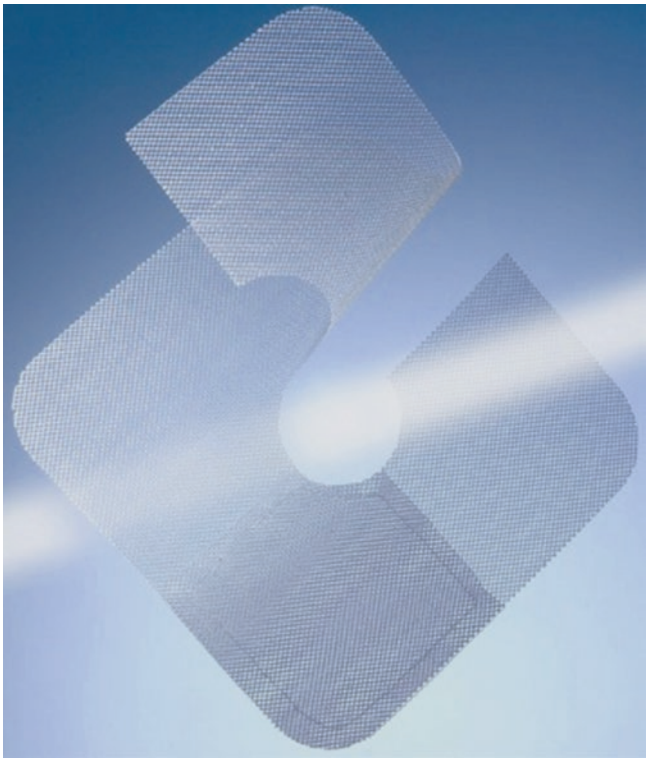

Fig. 7.223 TiLENE guard

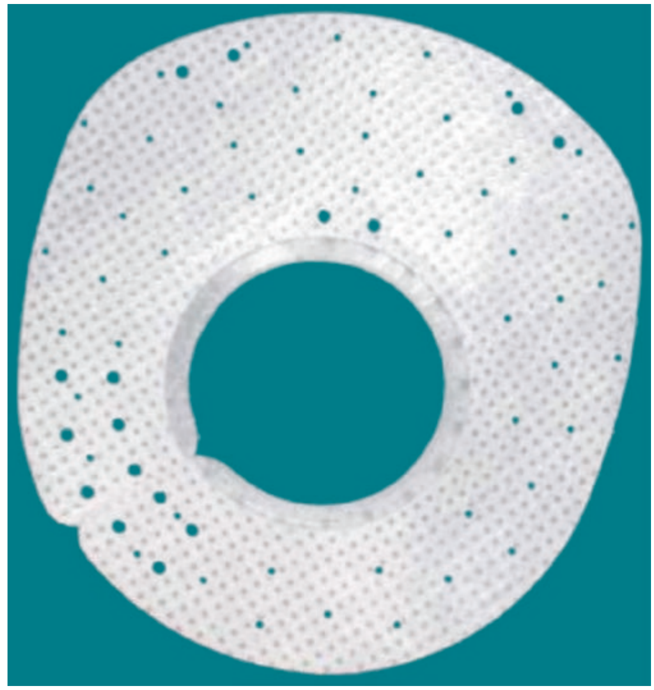

Fig. 7.224 RH implant

Table 7.23 Permanent hiatal hernia repair products

RH Implant, Microval, Saint-Just-Malmont, France
Parietex Composite (PCO) Hiatal Mesh, Medtronic, Minneapolis, MN, USA
TiLENE Hiatus, GfE Medizintechnik, Nuremburg, Germany
TiSURE, GfE Medizintechnik, Nuremburg, Germany

Fig. 7.225 Parietex composite hiatal mesh (All rights reserved. Used with Permission of Medtronic)

with a permanent prosthesis. While the application of flat meshes such as unprotected PP or POL has been used, these products were designed to mitigate against these concerns (Table 7.23).

The *RH Implant* is of the similar material of the other products from Microval (Fig. 7.224). It is non-woven PP coated on one side with silicon as the tissue-separating component. The larger perforations are used to suture the mesh in place.

Parietex Composite Hiatal Mesh is made of the same material as the parent PCO product (Fig. 7.225). It possesses a U-shaped defect that is slightly off-center that is to be positioned below the esophagus. The legs of the product will lie on the crura. It is available in two other shapes, a heart shape and a horseshoe shape.

TiLENE Hiatus is made of the titanized PP but in either a rectangle shape with a curve on one side or in an "hourglass" configuration. *TiSURE* is a rectangular mesh that has a central hole and a flap made from TiMESH (Fig. 7.226). It differs from the other products listed in that it possesses that flap which mandates complete encirclement of the esophagus. It can be fixed with either fibrin glue or sutures. It is not recommended to use metal fixation devices on this product because of the risk of complications from these devices.

Fixation Devices

Fixation devices became prevalent early in the development of the laparoscopic repair of hernias. They are mostly available as 5 mm versions as these have become

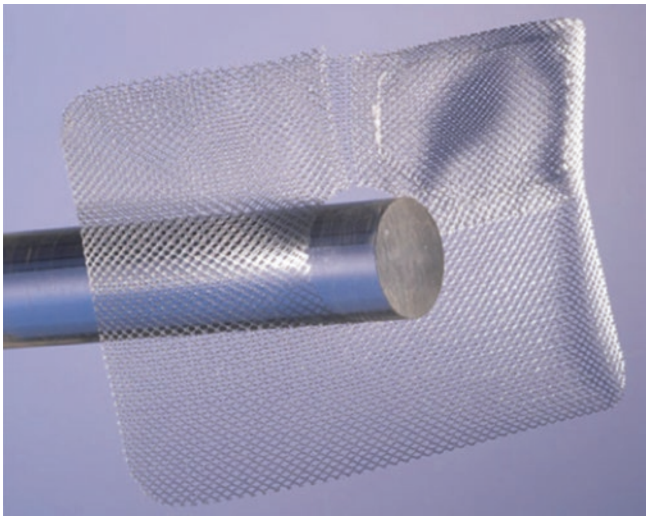

Fig. 7.226 TiSURE

Table 7.24 Fixation devices for hernia repair

AbsorbaTack, Medtronic, Minneapolis, MN, USA
CapSure, Davol, Inc., Warwick, RI, USA
DegraTack, TransEasy Medical Tech.Co.Ltd, Beijing, China
Endo Universal Stapler, Medtronic, Minneapolis, MN, USA
FasTouch, Via Surgical, Tel Aviv, Israel
iMesh Tacker, Corregio (RE), Italy
Multifire Endo Hernia Stapler, Medtronic, Minneapolis, MN, USA
Multifire VersaTack Stapler, Medtronic, Minneapolis, MN, USA
Optifix, Davol. Inc., Warwick, RI, USA
PermaFix, Davol, Inc., Warwick, RI, USA
ProTack, Medtronic, Minneapolis, MN, USA
ReliaTack, Medtronic, Minneapolis, MN, USA
SecureStrap, Ethicon Inc., Somerville, NJ, USA
SorbaFix, Davol, Inc., Warwick, RI, USA
Spire' it, Microval, Saint-Just-Malmont, France
Stat Tack, Medtronic, Minneapolis, MN, USA
Tacker, Medtronic Minneapolis, MN, USA
TiTack, TransEasy Medical Tech.Co.Ltd, Beijing, China

the most popular. Most recently, recognition of the fact that these fasteners are only needed on a temporary basis has led to the introduction of absorbable platforms. Currently, there is a variety of these devices that one may choose to fixate the meshes placed in hernia repair, whether inguinal or ventral and via an open or laparoscopic technique (Table 7.24). Surgeon preference and the mesh chosen will dictate the decision. One should consider the total length of these fasteners, as the depth of penetration will be dependent upon the thickness of the mesh used to repair the hernia. For example, a 5 mm fastener will provide no more of tissue penetration than 4 mm when used with 1 mm prosthesis. The reader is referred to the specific manufacturer of these products for more in-depth information.

Fig. 7.227 Absorbatack (All rights reserved. Used with Permission of Medtronic)

AbsorbaTack is a 5 mm fixation device and provides an absorbable synthetic polyester copolymer screw-like fastener derived from PGLA (Fig. 7.227). It measures 5.1 mm in length. It is offered in a short version for open repair with a 20-tack configuration. It is also available in a laparoscopic version with either 15 or 30 tacks. The tacks are significantly absorbed within 3–5 months with complete absorption within 1 year. *CapSure* is a permanent product, which has a smooth polyetheretherketone (PEEK) cap and screw threads that are made of 316 L stainless steel (Fig. 7.228). The *DegraTack* is an absorbable screw like tack and is also made of polylactide-co-glycolide (PGLA), which is also totally degraded in 12 months (Fig. 7.229). The iMesh tack is also an absorbable PGLA device (Fig. 7.230). The fasteners of this device have a depth of purchase of 5.2 mm. It has a large variety of loads of 10, 15, 20, 25, 30, or 38 tacks. The tip of the delivery device can articulate up to 60°.

FasTouch is a unique 5 mm device in that it does not employ any of the screw-like fasteners listed in this section (Fig. 7.231). It delivers a suture-like closed "locked" loop (Fig. 7.232). Its shape and size delivers the lowest amount of foreign body to fixate the mesh than any other available product. The permanent fastener is made of poly-carbonate-urethane (PCU). Although not available at the time of this writing, there will be an absorbable fastener available soon. It can be reloaded with either a 10 or 25 reload. The *Endo Universal Stapler* is to be used via a 10 or 12 mm trocar (Fig. 7.233, middle). It delivers a "box-type" staple of titanium and can be rotated 360° and has 65% of articulation. It can be used in four different positions. The *MultiFire Endo Hernia Stapler* is introduced through a 12 mm trocar (Fig. 7.233, upper). It also fires "box-shaped" staples that will fixate the prosthesis into which it is fired. They are both reloadable either 4.0 mm or 4.8 mm staples (Fig. 7.233, lower). The obvious difference is that the former product will articulate up to 65° while the latter does not. The *MultiFire VersaTack Stapler* is designed for usage during open hernia repair (Fig. 7.234). It, too, can be rotated 360° and is available with either the 4.0 or 4.8 mm staples with ten staples. These staples are usually acceptable for use with MRI and NMR up to 3 Tesla.

Fig. 7.228 CapSure

Fig. 7.229 DegraTack

Fig. 7.230 iMesh tack

Fig. 7.231 FasTouch device

Fig. 7.232 FasTouch suture-like fastener

Fig. 7.233 Endo Universal Stapler (middle), MultiFire Endo Hernia Stapler (upper), Reload cartridge (lower) ()

Fig. 7.234 Multifire Versatack (All rights reserved. Used with Permission of Medtronic)

The *OptiFix* device delivers a poly(D,L)–lactide (PDLLA) fastener that has two barbs on the end of it and two on the shaft (Fig. 7.235). They are delivered over an introducer needle. This product is available in either a 15 or 30 shot shaft. These fasteners are fully absorbed at 16 months. *PermaFix* and *SorbaFix* each deliver the same size (6.7 mm) screw-type fasteners by an identical delivery mechanism with a pilot tip and mandrel (Fig. 7.236). Both of these fasteners are available in either 15 or 30 devices delivered via a 5 mm product. Permafix is made of a grey molded permanent (non-absorbable) polymer. SorbaFix is made of the same purple absorbable material as OptiFix.

The *ProTack* was one of the older products that delivers a permanent titanium helical fastener by a 5 mm device (Fig. 7.237). It is available with 30 tacks. These are the easiest fixation products to visualize on a plain radiologic study. They are 3.9 mm in total length. *ReliaTack* is an articulating 5 mm device that also delivers a similar screw like absorbable tack (Fig. 7.238). It can be reloaded with a cartridge that contains either 5 or 10 fasteners. It is supplied with either a standard 5.1 mm device or the deep purchase tack that is 7.0 mm in length (Fig. 7.239). It is the only fastener that is available with two different lengths of tacks from which to choose.

The *SECURESTRAP* is pre-loaded with *25* absorbable straps (Fig. 7.240). The straps are composed of a blend of polydioxanone and L(−)-lactide and glycolide dyed with D&C Violet No. 2. This product does not screw into the tissues and has two legs similar to the staplers. The ends of these straps are barbed to aid in fixation. The width between the points is 3.5 mm. The entire device's length is 6.7 mm but the distance from the inner portion of the strap to the point of fixation of the strap is 4.9 mm (i.e., the "grip"). It also is available with a curved shaft for open repair (Fig. 7.241). *Spire' It* is a different device in that it is made of nitinol and advances in the shape of a ring once fully formed (Fig. 7.242). There are two turns of the ring with a final form of 4 mm. It is re-loadable and is available in a 7 cm length for open surgery or a 30 cm length for laparoscopic surgical applications.

Fig. 7.235 OptiFix

Fig. 7.236 PermaFix (left), Sorbafix (right)

Fig. 7.237 ProTack (All rights reserved. Used with Permission of Medtronic)

Fig. 7.238 Reliatack (All rights reserved. Used with Permission of Medtronic)

The *Stat Tack* and *Tacker* devices deliver helical titanium tacks virtually identical to the ProTack (Figs. 7.243 and 7.244). The former device is shorter and designed for open hernia repair, delivering only 15 tacks. The *Tacker* is longer as it is designed for laparoscopic techniques and delivers 30

Fig. 7.239 Reliatack standard or deep purchase tack (All rights reserved. Used with Permission of Medtronic)

Fig. 7.240 SECURESTRAP (Image courtesy of Ethicon, Inc.)

Fig. 7.241 SECURESTRAP Open (Image courtesy of Ethicon, Inc.)

Fig. 7.242 Spire' it

Fig. 7.243 Stat tack (All rights reserved. Used with Permission of Medtronic)

Fig. 7.244 Tacker (All rights reserved. Used with Permission of Medtronic)

tacks in the single use device. There is an available multi-use handle of the *Tacker* that can be attached to an available tube of 20 tacks. The multiuse product has a shorter tube than the single use product. The *TiTack* is another permanent titanium screw like device that has a similar appearance to the devices listed above (Figs. 7.245 and 7.246). There are significant differences in configuration, depth of penetration and exposed "head" of these devices (Fig. 7.247). These variations should influence the choice of product to fixate any mesh material.

Fig. 7.245 TiTack device

Fig. 7.246 TiTack fasteners

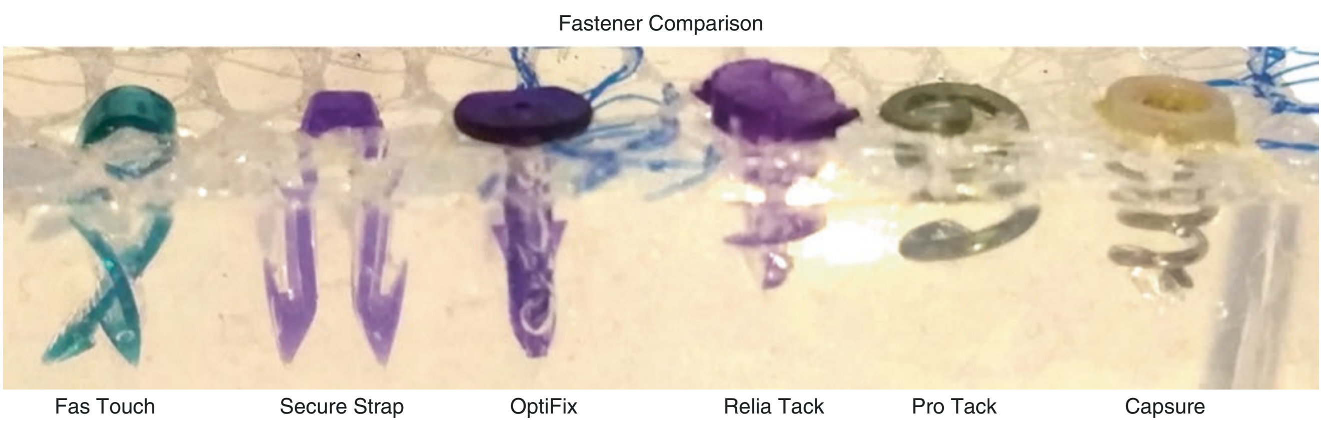

Fig. 7.247 Comparison of fixation fasteners

Conclusion

The use of a prosthetic material for all hernia repairs is generally considered the standard of care unless there are extenuating circumstances. The purpose of this chapter is to identify and differentiate the products that can be used in hernioplasties. It is as complete as I could make this at this time. Undoubtedly by the time of the printing of this textbook others will have become available. The surgeon should choose carefully.

I believe that the ideal material has not yet been developed. There are, however, many that have been described above that do function quite well for the surgeon and the patient. Perhaps in the future, the use of genetic engineering will produce a product that is based from the protein of the patient and will allow the patient to incorporate a "natural" and "native" product into the tissues without fear of infection or adhesions. A permanent solution to the quest of the perfect biomaterial may be the result.

Acknowledgement Although it is not designated on the propriety names of most of the products listed in this chapter, it should be acknowledged to the reader that all manufacturer names and products are either registered trademarks, copyrighted or exclusive to that company. These cannot be used without the permission of the respective company.

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