5 Implants Used 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 is 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]. There are numerous other papers that reinforce this fact.

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 to 11% but averages approximately 5.5%. There are a variety of factors that influence recurrence rates that are discussed in other chapters of this text. 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 many different products that can be used in the repair of 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

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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 and current product availability 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 5.1.

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 significant 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 predisposing factors such as emphysema or the chronic bronchitis of individuals that smoke tobacco products results 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 a 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.

Table 5.1 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)

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 or traumatic events. 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 text. Mesh materials are necessary for these problems to assure as durable a repair as feasible.

All of these biomaterials were attempting to address the “ideal characteristics” that were promulgated by Cumberland and Scales [6, 7]. 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 5.2).

Table 5.2 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 5.3 Ideal surgical clinical characteristics of synthetic products

Permanent repair of the abdominal wall (i.e., no recurrences)
Ingrowth 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

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 noncarcinogenic, the clinical characteristics of the "ideal surgical" material are listed in Table 5.3.

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 nonabsorbable products. The synthetic nonabsorbable 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 nonabsorbable 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 an 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. Additionally, due to the recent surge in techniques that allow the placement of mesh in different layers of the abdominal wall, the reader should be certain that the products described here can be used in the location that is selected during the operation in which it is used.

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 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 products is the temporary replacement of absent tissue (Table 5.4).

Table 5.4 Absorbable products

Bio-A, W. L. Gore & Associates, Elkhart, DE, USA
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 ST mesh, CR Bard, Providence, RI, USA
Vicryl (knitted) mesh, Ethicon, Inc., Somerville, NJ, USA
Vicryl (woven) mesh, Ethicon, Inc., Somerville, NJ, USA

The strength of these materials and the lack of permanency make some of them unsuitable for the permanent repair of any hernia (although research is being conducted on this question). Newer research has suggested that they 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 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 sheet (Fig. 5.1). 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 [8].

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. 5.2). 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.

Fig. 5.1 Bio-A

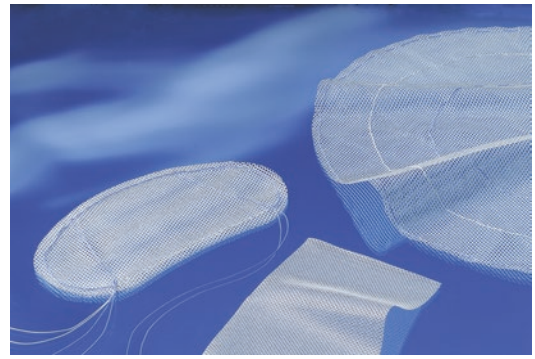

Fig. 5.2 Safil mesh

Phasix is composed of poly-4-hydroxybutyrate (P4HB). This is produced from byproducts of *E. coli* metabolism (Fig. 5.3). It is degraded by hydrolysis and hydrolytic enzymatic processes. The absorption of the material is minimal until about 26 weeks postimplantation and is essentially complete in about 52 weeks. The material is also available with a barrier coating of carboxymethylcellulose and hyaluronic acid as *Phasix ST* (Fig. 5.4). 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. 5.5). The Matrix is warp-knitted in a proprietary way, allowing it to

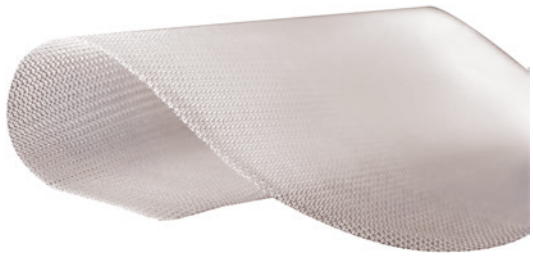

Fig. 5.3 Phasix mesh

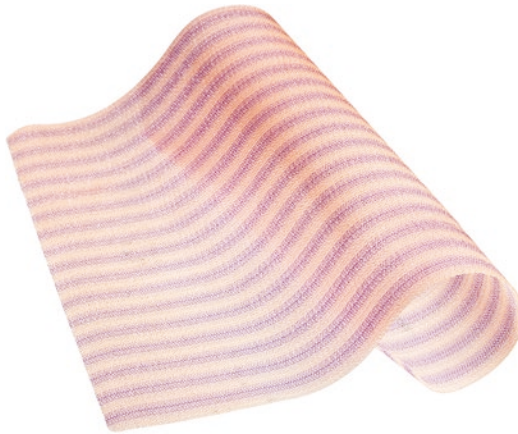

Fig. 5.4 Phasix ST

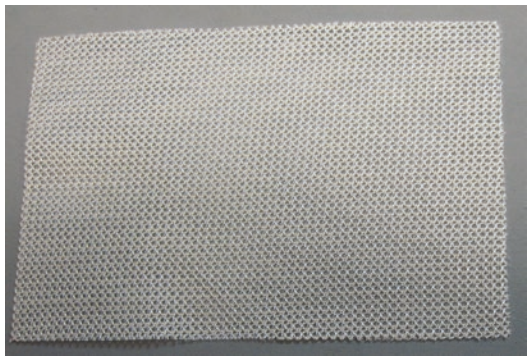

Fig. 5.5 TIGR mesh

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.

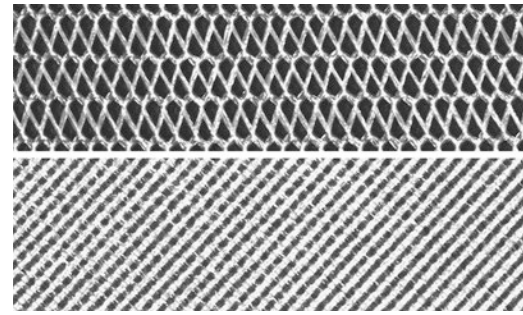

Fig. 5.6 Vicryl (knitted) and woven (lower). (Images courtesy of Ethicon, Inc.)

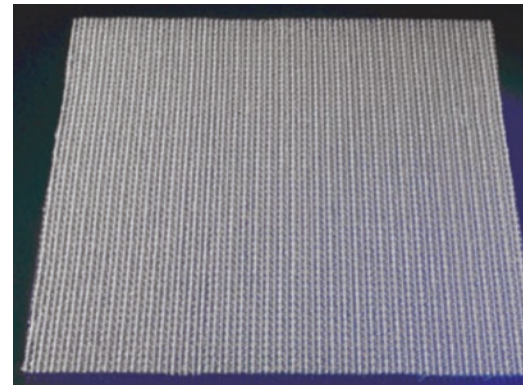

Fig. 5.7 Dexon mesh

The *Vicryl* and *Dexon* meshes are primarily polylactic acid (Figs. 5.6 and 5.7). 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 of sufficient durability to formally repair a defect. Most frequently these are used to provide a buttress of support for the temporary closure of an infected incisional wound of the abdomen or in the patient with intra-abdominal sepsis or abdominal compartment syndrome. They have also been used in the treatment of complex or very large hernias that will be repaired in a staged fashion. In that instance, this product will be placed as a bridge and the patient will be returned to the operating room within a few days to perform the definitive procedure. These represent a less costly alternative to biologic materials for this application.

Biologic Products

These products do not represent a new concept in hernia repair and were used in the early 1900's. They are a marked improvement over 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 postimplantation.

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 noninfected 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 be 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 5.5). Only the *SurgiMend* is fetal (dermal) tissue (Fig. 5.8). 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

Table 5.5 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, Baxter Healthcare Corporation, Deerfield, IL, USA

Fig. 5.8 SurgiMend 1-2-3-4

(Fig. 5.9). 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. 5.10).

Tutomesh and *Tutopatch* are of the same source (pericardium) and are processed in the same manner (Figs. 5.11 and 5.12). 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 (Fig. 5.13). The use of all of these bovine products has generally been limited to the incisional hernia repair.

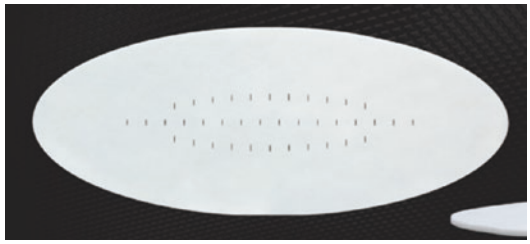

Fig. 5.9 SurgiMend-e

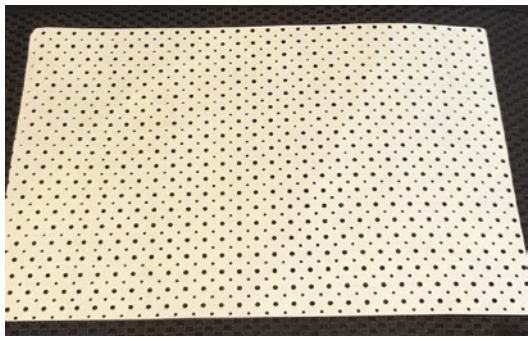

Fig. 5.10 Surgimend MP

Fig. 5.11 Tutomesh

Fig. 5.12 Tutopatch

Fig. 5.13 Veritas

Cadaveric Products

The human cadaveric products have a long history (Table 5.6). There is significant variability in the amount of stretch that each of these will undergo either at the time of implantation and 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. 5.14). *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 *Cortiva 1 mm* is 1 mm (0.8–1.2 mm) (Fig. 5.15). *DermaMatrix* is used for hernia repair but is additionally used for purposes other than hernia

Table 5.6 Cadaveric biologic prostheses

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

Fig. 5.14 Allomax

Fig. 5.15 Cortiva

Fig. 5.16 DermaMatrix

repair (Fig. 5.16). 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.

Porcine Products

There are a number of these materials that are available (Table 5.7). 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. 5.17, 5.18, and 5.19). They are all developed from por-

Table 5.7 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

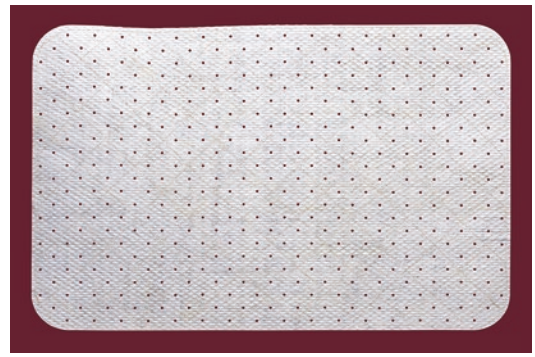

Fig. 5.17 Biodesign hernia graft

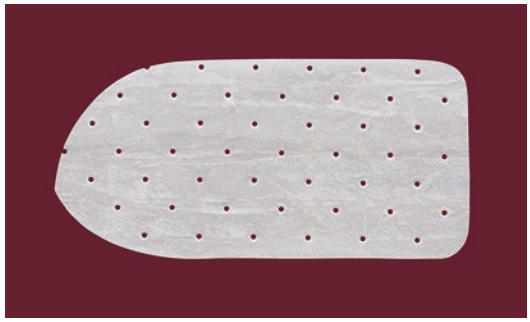

Fig. 5.18 Biodesign inguinal hernia graft

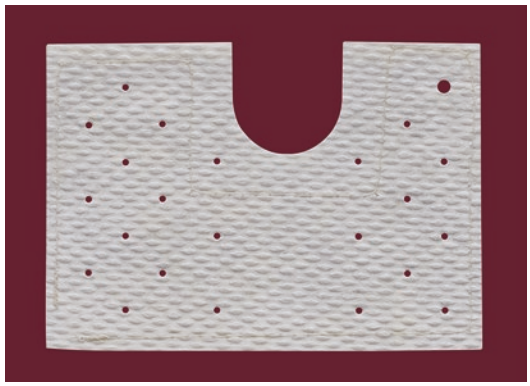

Fig. 5.19 Biodesign hiatal hernia graft

Fig. 5.20 Cellis

cine 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. 5.20). It also requires rehydration. *Fortiva* originates from dermis but does not require hydration (Fig. 5.21). *Gentrix Surgical Matrix* is also a laminated product. It is unique in

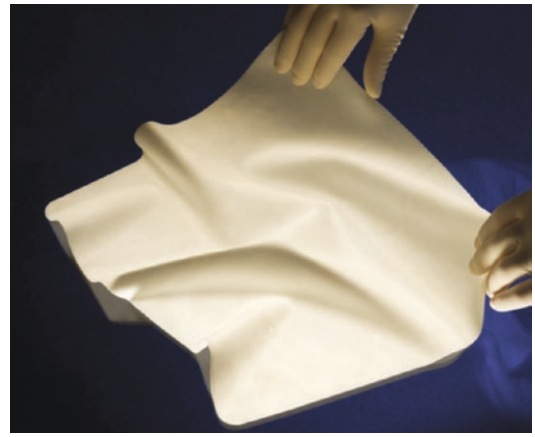

Fig. 5.21 Fortiva

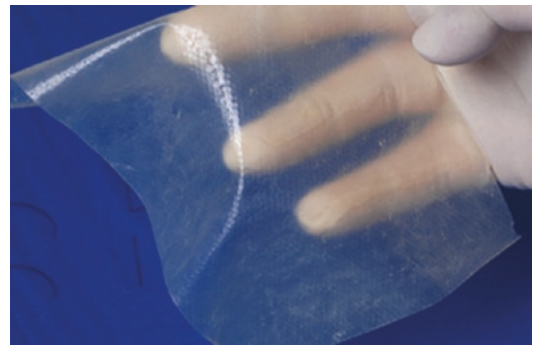

Fig. 5.22 Gentrix RS

this biologic category as it is the only one that is made from the urinary bladder of the pig. All of these 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* (three ply), *PSM* (six ply), or *PSMX* (eight ply) and *Plus* (eight ply). The only real difference in the latter is the size of the product itself, the latter being the larger available material (Figs. 5.22, 5.23, 5.24, and 5.25). *Permacol* is a dermal collagen-based product that is the only material listed that is cross-linked and does not require rehydration (Fig. 5.26). 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.

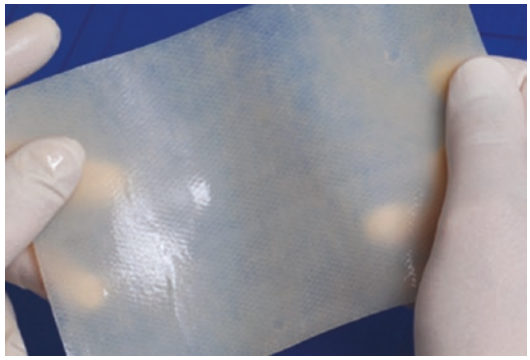

Fig. 5.23 Gentrix PSM

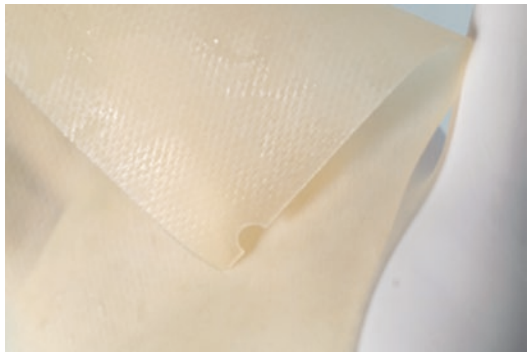

Fig. 5.24 Gentrix PSMX

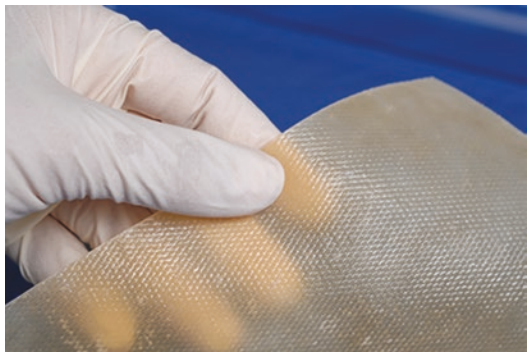

Fig. 5.25 Gentrix Plus

Fig. 5.26 Permacol (All rights reserved. Used with permission of Medtronic)

Fig. 5.27 Strattice firm

Fig. 5.28 Strattice laparoscopic

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 in many sizes, which depend upon which version is selected. These versions include a pliable and preshaped pliable, a firm (Fig. 5.27), a laparoscopic (Fig. 5.28), and a perforated version (Fig. 5.29). The Strattice Firm has a thickness 1.76 ± 0.012. The selection will

Fig. 5.29 Strattice perforated

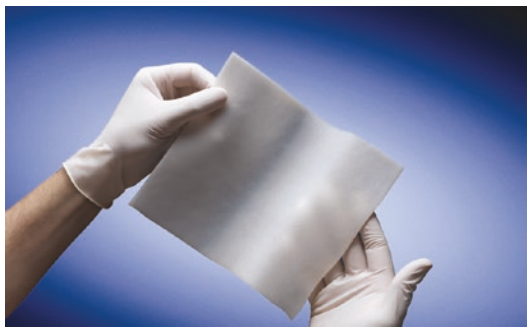

Fig. 5.30 XenMatrix

depend on type of hernia to be repaired and the area to be covered. This is the only biologic product that has a specific version that is designed for use laparoscopically. *XenMatrix* is also dermal based and is not cross-linked (Fig. 5.30). It does require rehydration but not refrigeration. It is one of the thickest porcine biologics due to its 1.95 ± 0.012 measurement. 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. 5.31). It

Fig. 5.31 XenMatrix AB

Fig. 5.32 XCM

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. 5.32). 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

Table 5.8 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
Synecor Pre, W. L. Gore & Associates, Elkhart, DE, USA
Zenapro, Cook Medical, Bloomington, IL, USA

of collagen deposition to enhance the healing process. These materials seek to capitalize on the benefits of both of these concepts (Table 5.8). There is relatively little data on the actual results of the use of these materials but these data will undoubtedly be researched in the future.

OviTex, OviTex 1S and 2S is the most recent additions to these class of meshes. 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 (Fig. 5.33). *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. 5.33, middle and lower). Because of these differing designs, the thickness varies from 0.9 to 1.1 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 IP has combined some older materials together (Fig. 5.34). 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. 5.34, left). The visceral (tissue-separating) side is PGA/TMC and is a different structural weave which is quite tight to prevent ingrowth (Fig. 5.34, right). This material can be used either dry or wet. *Synecor Pre* is has the

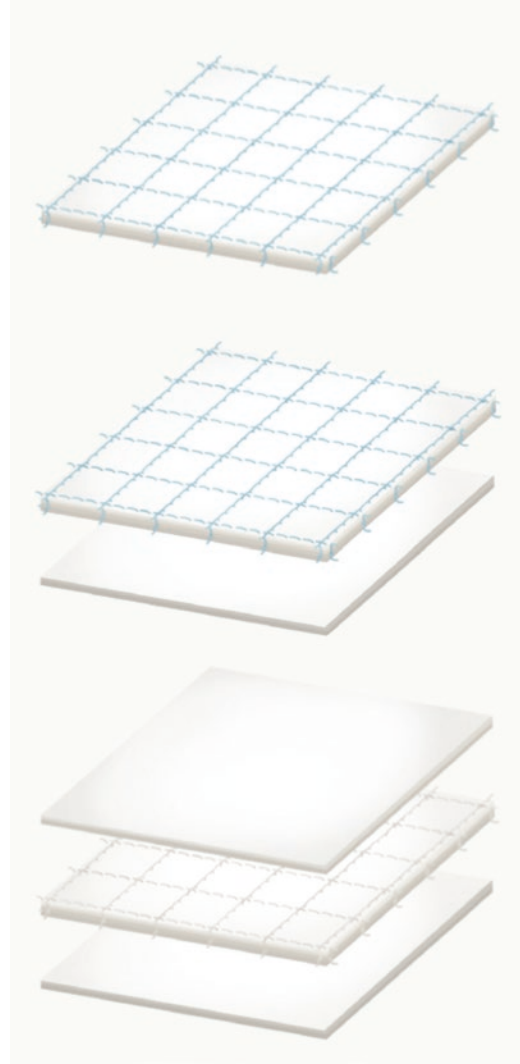

Fig. 5.33 Ovitex 1S, 2S

Fig. 5.34 Synecor IP

Bio-A coating on both sides of the PTFE and is designed to be placed in the extraperitoneal plane and should not be used against the viscera (Fig. 5.35).

Zenapro is the oldest of these three products (Fig. 5.36). 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." It is no longer available.

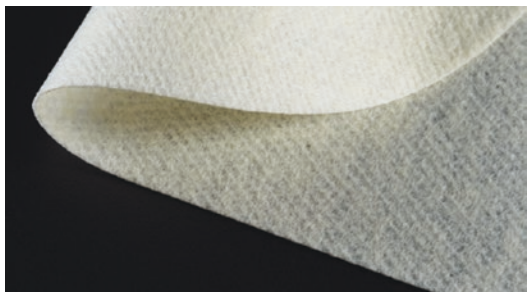

Fig. 5.35 Synecor Pre

Fig. 5.36 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 5.9). These should be used either in laparoscopic

Table 5.9 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 UL, Di.pro Medical Devices, Torino, Italy
Bulev B5050, 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

(continued)

Table 5.9 (continued)

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, Atrium Medical Corporation, Hudson, NH, 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, USA
VitaMesh Blue—Getinge Group, Wayne, NJ, USA

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. Many of the figures below include the configurations of the inguinal applications due to the fact that most are available for this use.

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 nonwoven PP material that is available in three different weights and thicknesses (Fig. 5.37). These meshes are configured in a variety of shapes and sizes as shown.

Basic mesh is a lightweight mesh (Fig. 5.38). Di.pro has developed an ultra lightweight version that is called *Basic Evolution* mesh (Fig. 5.39). *Bard Mesh* is probably the oldest flat sheet of

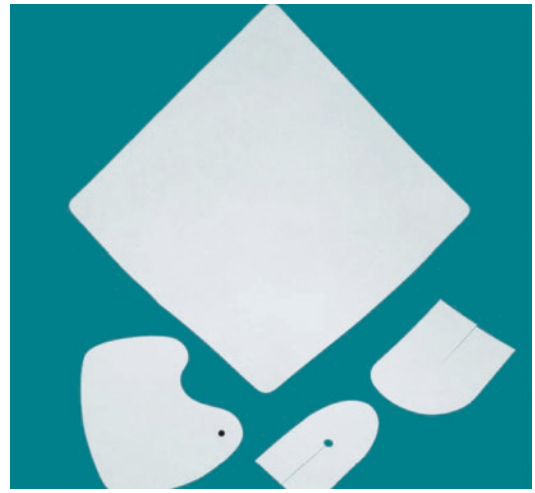

Fig. 5.37 2D PPNT

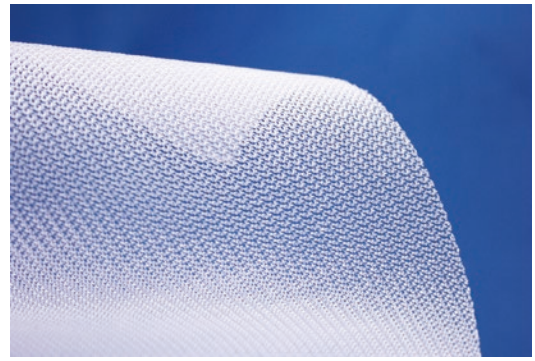

Fig. 5.38 Basic mesh

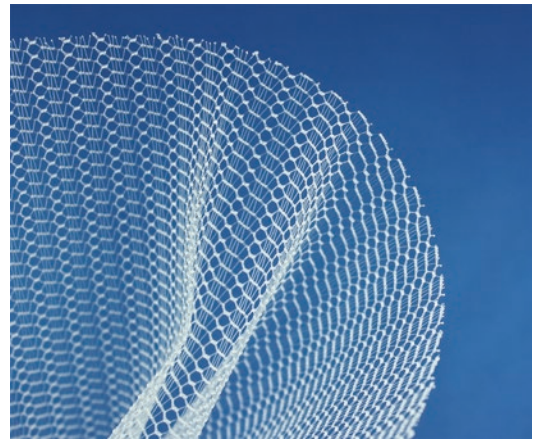

Fig. 5.39 Basic evolution

heavy weight polypropylene in existence, having been brought to market in the early 1960s (Fig. 5.40). 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. 5.41). *Biomesh P1* is the standard weight material compared to the *Premium* (Figs. 5.42 and 5.43). 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. 5.44 and 5.45). The weights of the Bulev products are 48 g/m^2 and 39 g/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

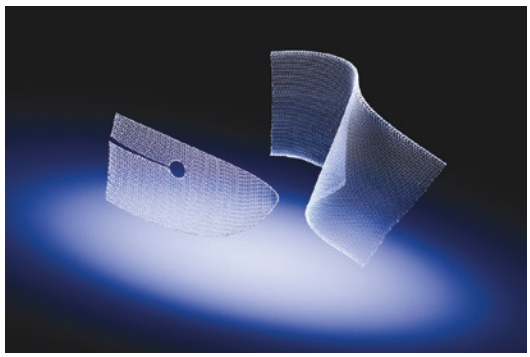

Fig. 5.40 Bard mesh flat and preshape

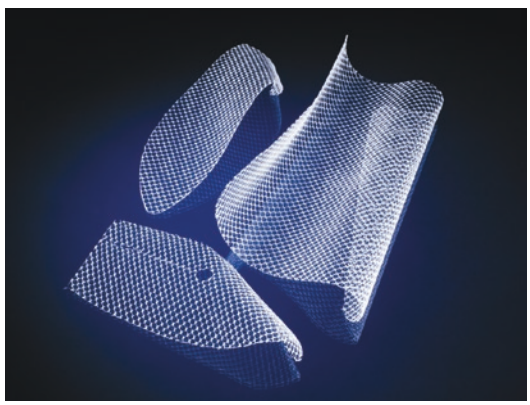

Fig. 5.41 Bard soft mesh

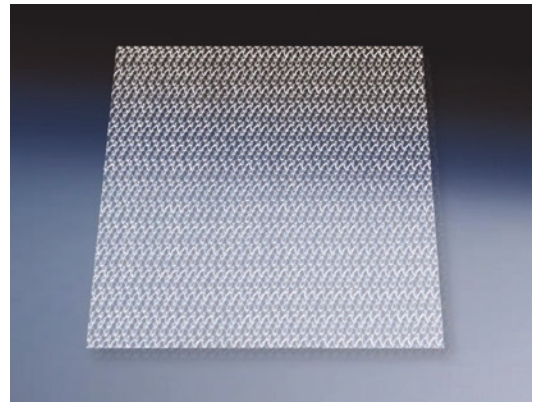

Fig. 5.42 Biomesh P1

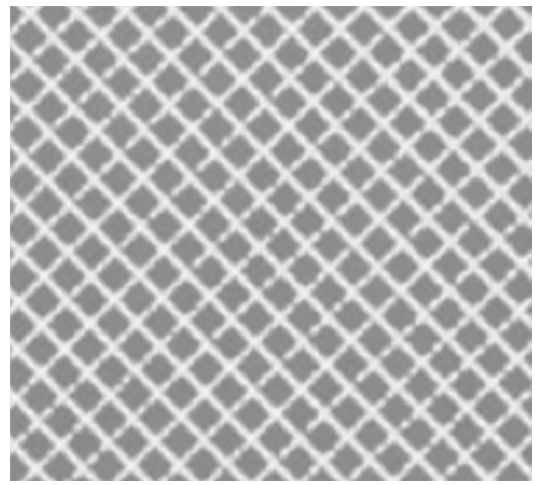

Fig. 5.43 Premium mesh

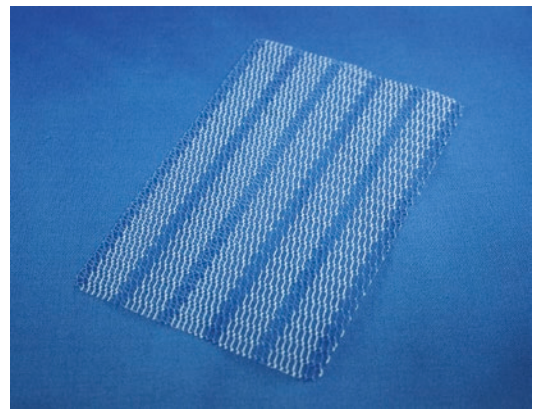

Fig. 5.44 Bulev B

Fig. 5.45 Bulev UL

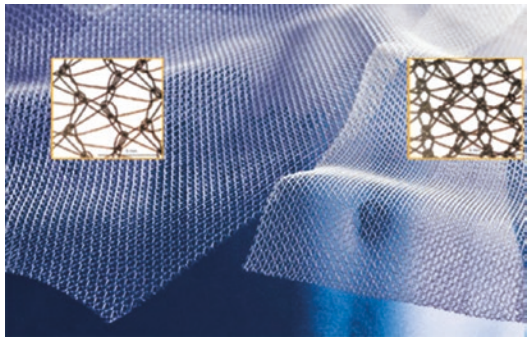

Fig. 5.46 DynaMesh light and standard

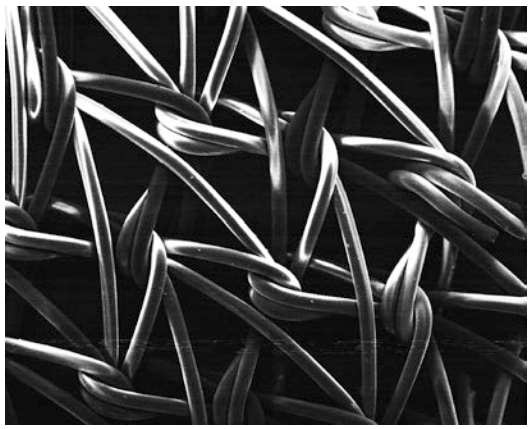

Fig. 5.47 Easy Prothes heavy weight PP.

(Fig. 5.46). *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 5.47, 5.48, 5.49, and 5.50 detail the differences in the weaves of the products. Figures 5.51 and 5.52 compare the medium and

Fig. 5.48 Easy Prothes 70

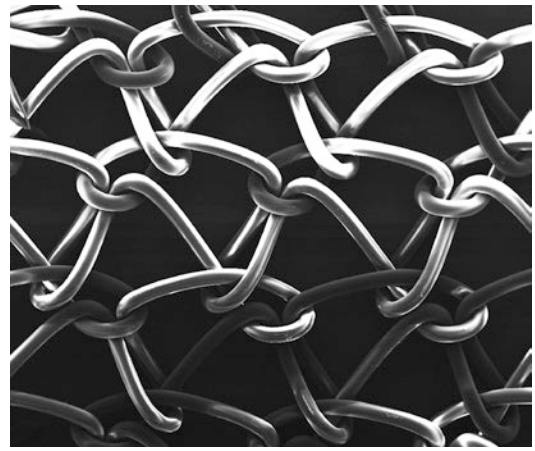

Fig. 5.49 Easy Prothes 60

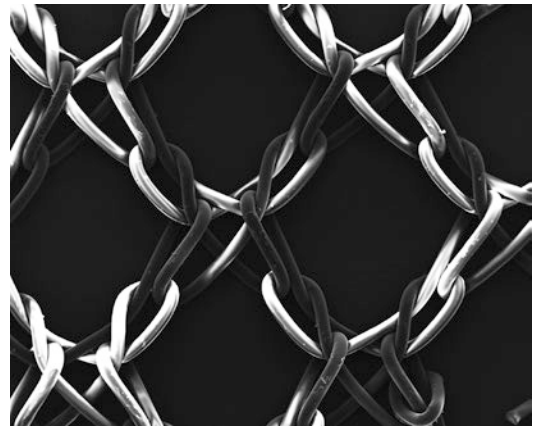

Fig. 5.50 Easy Prothes lightweight

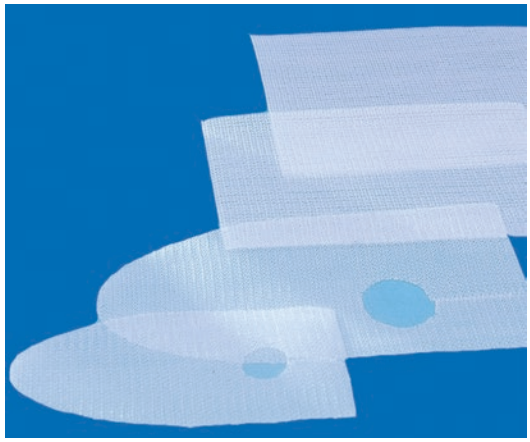

Fig. 5.51 Easy Prothes 60

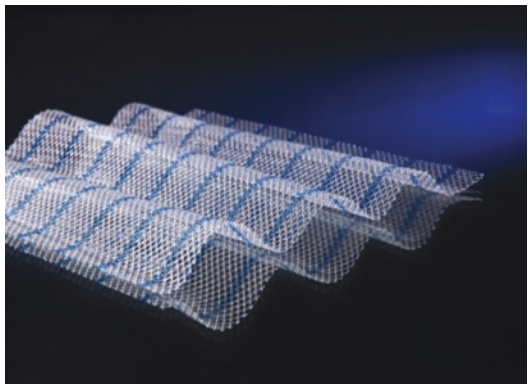

Fig. 5.52 Easy Prothes lightweight

lightweight versions. The *Hermesh 3–8* have a huge variety of weights and sizes and can be used in either open or laparoscopic repairs (Fig. 5.53). 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. 5.54). The production of this product was stopped prior to the publication of this textbook).

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 multidirectional elasticity (Figs. 5.55, 5.56, and 5.57). Unlike some of the other prostheses, the blue lines in the Optilene do not signify an absorbable component. *Parietene Flat Sheet and Parietene*

Fig. 5.53 Hermesh variety

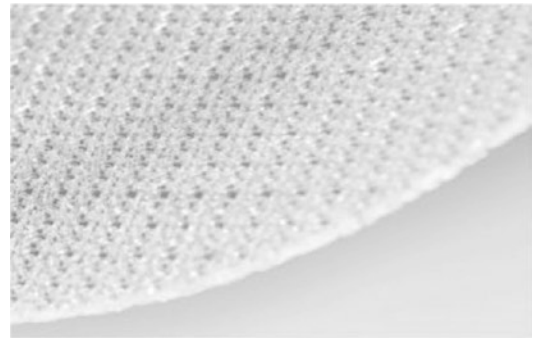

Fig. 5.54 Lapartex (It is no longer available)

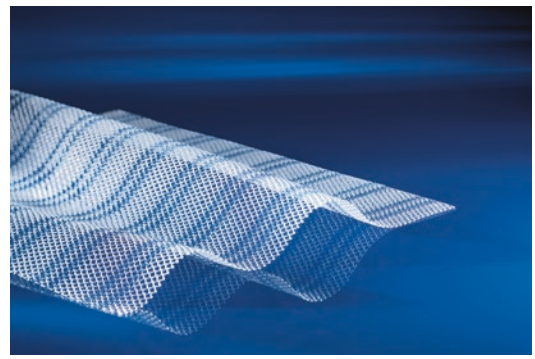

Fig. 5.55 Optilene

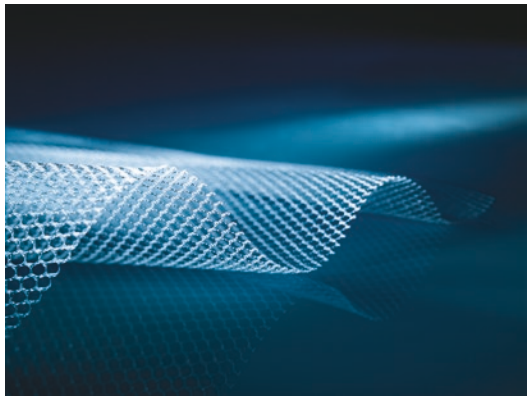

Fig. 5.56 Optilene mesh Elastic

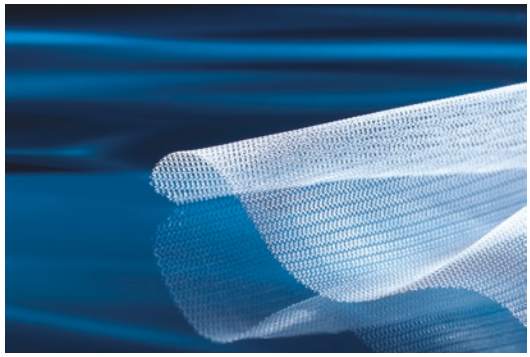

Fig. 5.57 Optilene mesh LP

Fig. 5.58 Parietene flat sheet (All rights reserved. Used with permission of Medtronic.)

Lightweight products are monofilament flat sheet products (Fig. 5.58). *Premilene* is the heaviest weight (82 g/m^2) product in the Braun flat mesh product line (Fig. 5.59). *Prolene* is also a heavier weight mesh material and it is one of the older products available (Fig. 5.60). *Prolene Soft Mesh*

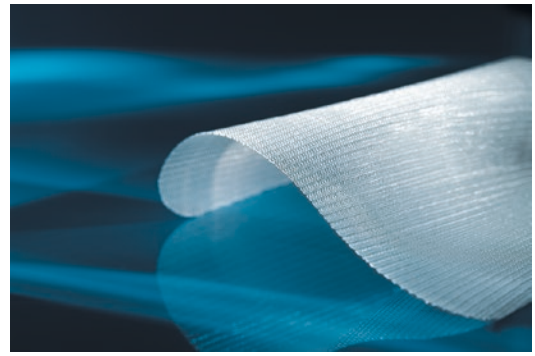

Fig. 5.59 Premilene mesh

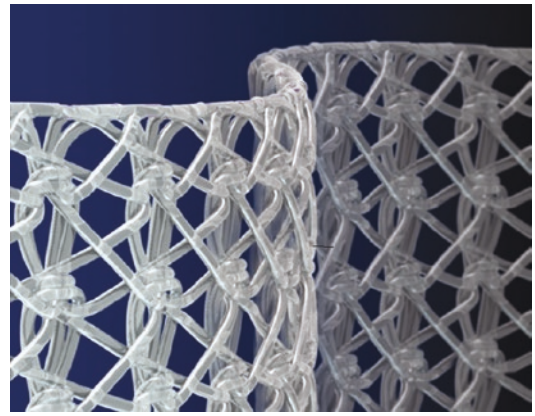

Fig. 5.60 Prolene (Image courtesy of Ethicon, Inc.)

is the lighter weight version that has larger pores than the original mesh and blue lines to help differentiate it (Fig. 5.61). *ProLite* was one of the earliest meshes that were introduced as a lighter weight material (Fig. 5.62). Today, it is considered a mid-weight mesh. *ProLite Ultra* possesses even less weight of mesh than ProLite (Fig. 5.63).

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 nonwoven microfiber PP product that is extremely lightweight and has a differing microstructure than the other materials listed in this section (Fig. 5.64). 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. 5.65). Because of the demand for a monofilament product, the second-generation

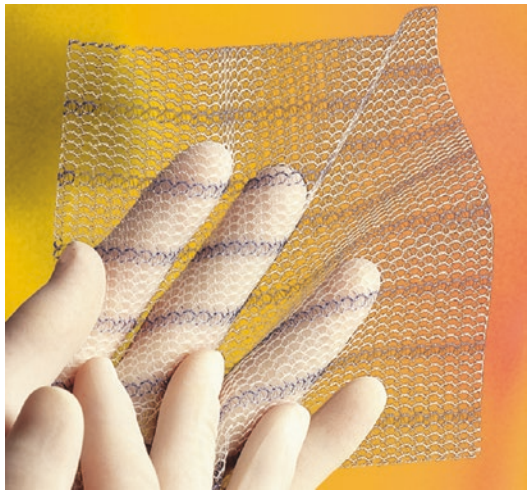

Fig. 5.61 Prolene soft mesh (Image courtesy of Ethicon, Inc.)

Fig. 5.63 ProLite Ultra

Fig. 5.62 ProLite

Fig. 5.64 SurgiMeshWN

product was released (Fig. 5.66). The multifilament material is noticeably softer than the monofilament one. There is now an open weave product called the *Surgipro Open Weave* (Fig. 5.67). *SMX* is a heavy product designed for all hernia repairs (Fig. 5.68). 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. 5.69).

TiMESH is similar to the lightweight materials but has a bonded layer of titanium on the fibers of the PP using nanotechnology (Figs. 5.70 and 5.71). This is supposed to allow ingrowth in a flexible manner while inhibiting the development of a scar plate. It can be used in either

Fig. 5.65 Surgipro multifilamented (All rights reserved. Used with permission of Medtronic.)

Fig. 5.66 Surgipro monofilamented (All rights reserved. Used with permission of Medtronic.)

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 extraperitoneal planes (Fig. 5.72). 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

Fig. 5.67 Surgipro open weave (All rights reserved. Used with permission of Medtronic.)

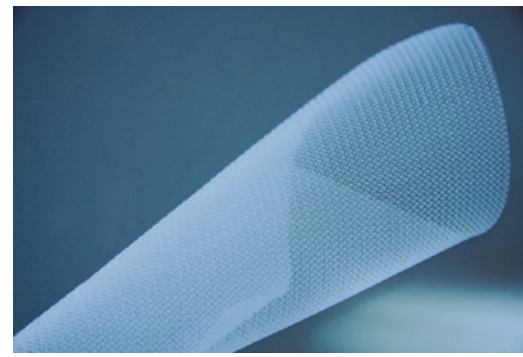

Fig. 5.68 SMX

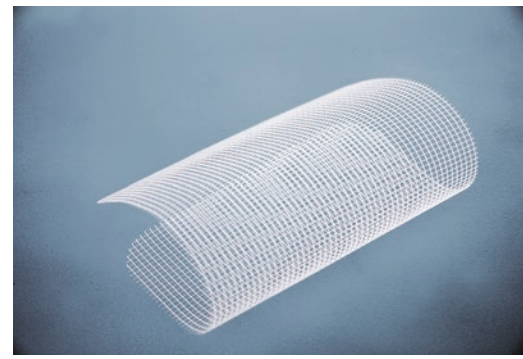

Fig. 5.69 SMH2

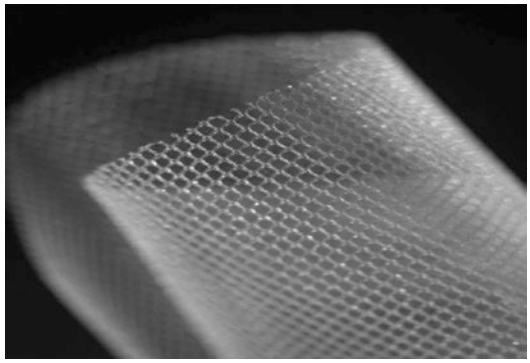

Fig. 5.70 TiMESH

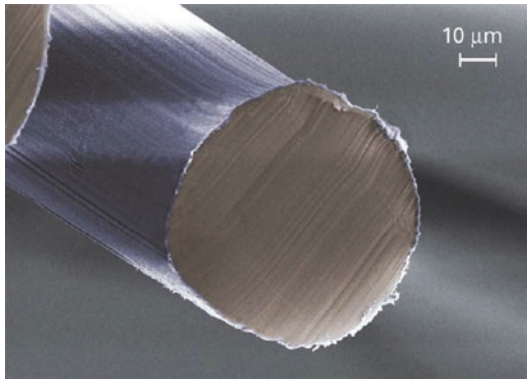

Fig. 5.71 TiMESH SEM

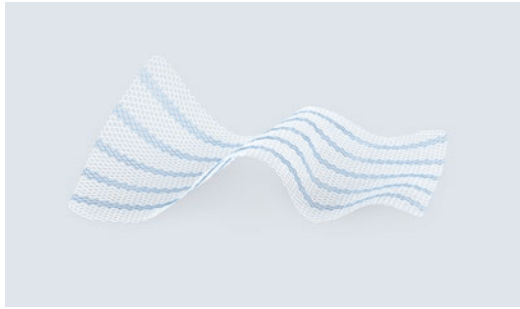

Fig. 5.72 TiLENE Blue

laparoscopic repair (Fig. 5.73). *VitaMesh Blue* is the lighter weight version (28 g/m^2) of this flat mesh and is differentiated by its blue color (Fig. 5.74). These products are singular in that they are made of condensed PP rather than the traditional PP. Regular PP mesh becomes condensed PP mesh through compression during a post-knit heat treatment. This condensing process serves

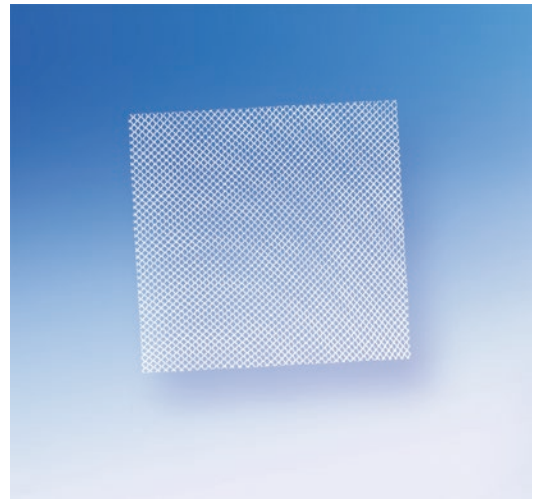

Fig. 5.73 VitaMesh

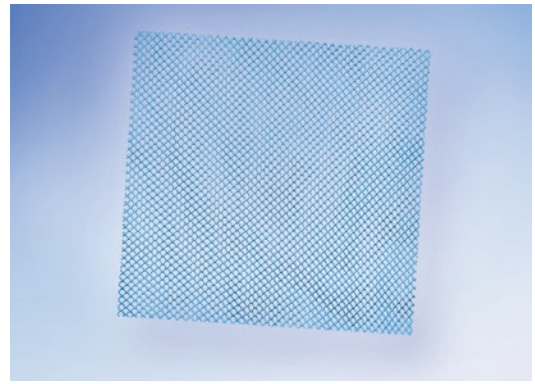

Fig. 5.74 VitaMesh Blue

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. 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 a scar plate with the 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.

There are relatively fewer non-coated polyester mesh materials (Table 5.10). The preponderance of the polyester products that are currently available is produced in various configurations and most have some type of coating and 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, has been configured into various shapes and sizes for a variety of applications (Figs. 5.75 and 5.76). *Angimesh*

Table 5.10 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

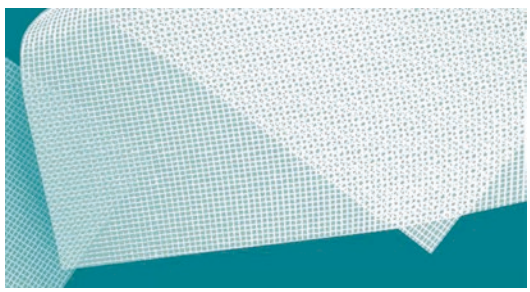

Fig. 5.75 2D PET

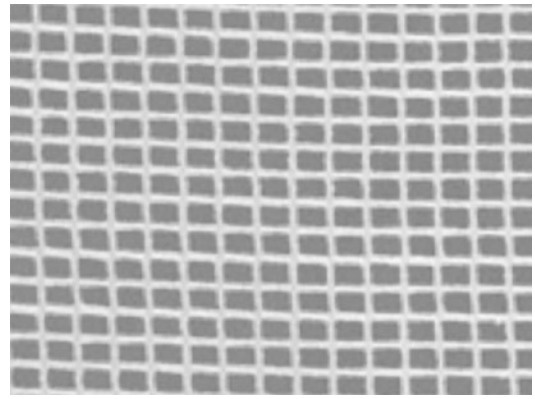

Fig. 5.76 Biomesh A2

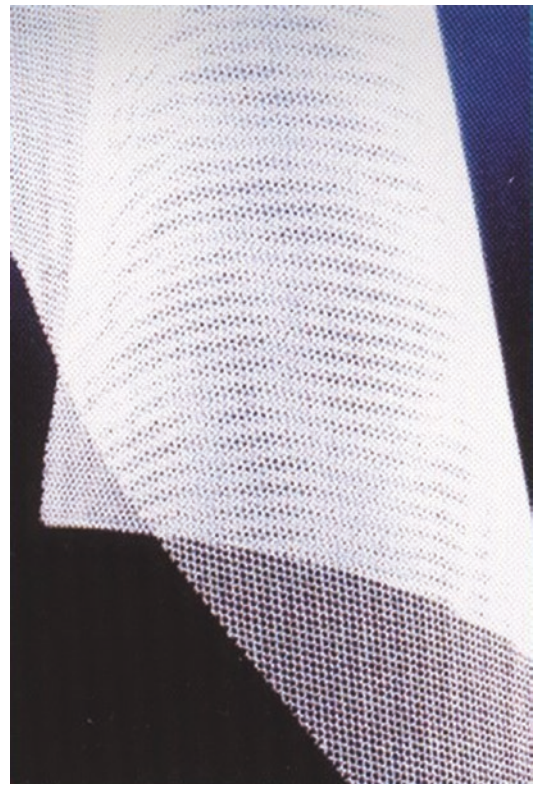

Fig. 5.77 Angimesh R2

R2 is multifilament polyester (Fig. 5.77). *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. 5.78 and 5.79). *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

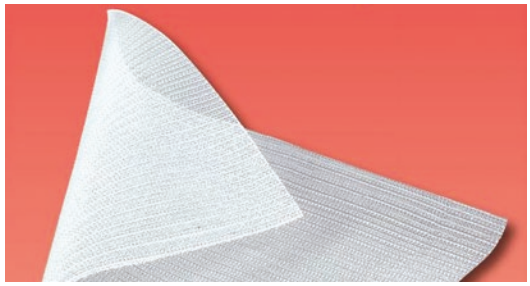

Fig. 5.78 Angimesh R2-1

Fig. 5.79 Angimesh R2-9

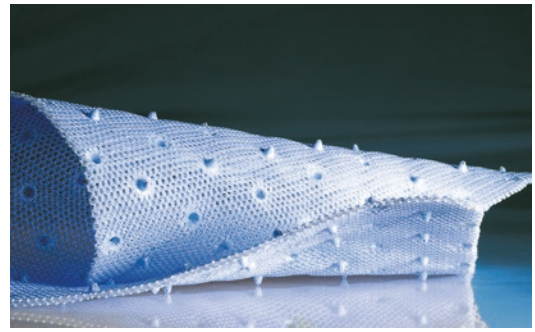

Fig. 5.80 CO3+

Fig. 5.81 Parietex flat sheet (All rights reserved. Used with permission of Medtronic.)

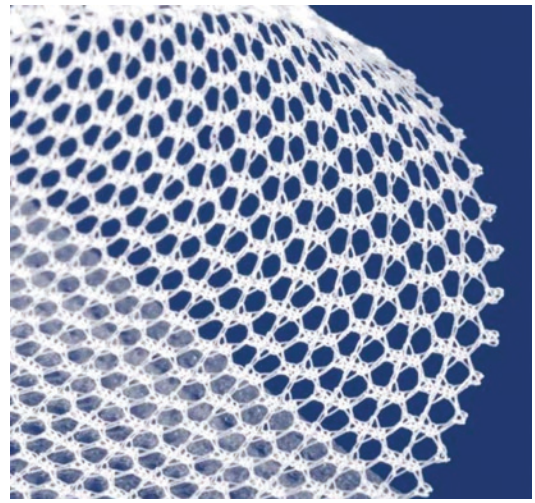

Fig. 5.82 Parietex lightweight mesh (All rights reserved. Used with permission of Medtronic.)

mentioned later in the chapter again. It is a three-dimensional weave of polyester that has impregnated polyurethane (PUR). The differentiating factor are the knitted "grips" that are on both sides of the product (Fig. 5.80). These are designed to fixate the mesh. It can be used in open or laparoscopic surgery and for nearly all hernias.

The *Parietex Flat Sheet Mesh* is available in two- or three-dimensional weaves (Fig. 5.81). 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. 5.82). *Parietex Monofilament Macroporous* is available in a flat sheet and is a two-dimensional construct (Fig. 5.83). *SM2* is a heavyweight bidimensional weave material that is indicated for all hernia repairs (Fig. 5.84).

SM3 and *SM3+* are three-dimensional weaves of polyester (Figs. 5.85 and 5.86). Both are available in a variety of shapes and sizes and can be used in open or laparoscopic 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. 5.87). It is a medium weight (64 g/m^2) monofilament product that is designed for placement in the preperitoneal space. It also has a central teardrop.

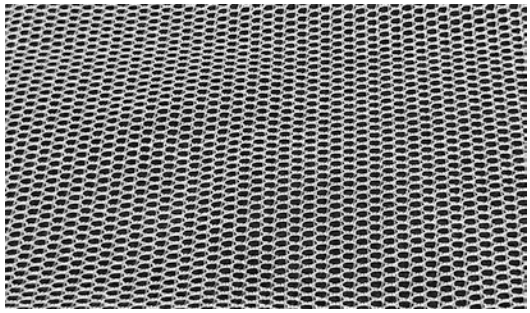

Fig. 5.83 Parietex monofilament macroporous (All rights reserved. Used with permission of Medtronic.)

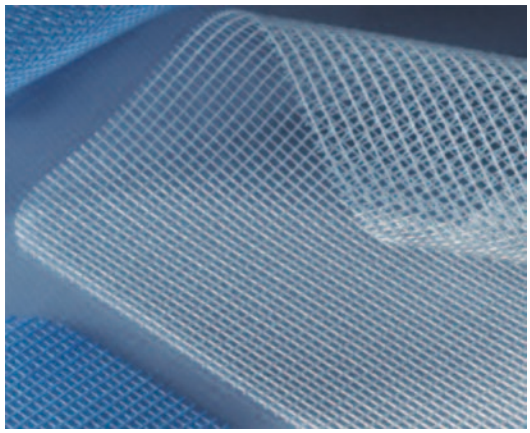

Fig. 5.84 SM2

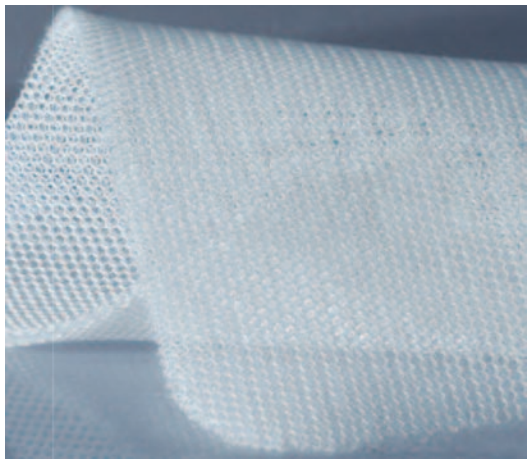

Fig. 5.85 SM3

Fig. 5.86 SM3+

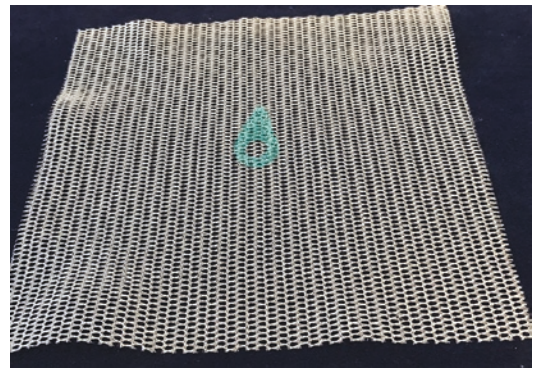

Fig. 5.87 Versatex (All rights reserved. Used with permission of Medtronic.)

Table 5.11 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

Expanded polytetrafluoroethylene (ePTFE) prostheses have also been available in a flat sheet configuration for many years (Table 5.11). In fact, the earliest products used in the intraperitoneal space for incisional hernia repair were of ePTFE [4]. 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. 5.88). These all have two distinctly different surfaces. One side is very smooth and has interstices of three microns 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 penetration will occur. *DualMesh* is available in one thickness, 1 mm. It is available with or without the impregnation of silver and chlorhexidine as *DualMesh PLUS* (Fig. 5.89). The 2-mm product is only available as DualMesh Plus with the antimicrobial agents within it. These two antimicrobial agents 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 permanent materials impregnated with any type of any antimicrobial or bactericidal agents. *DualMesh PLUS with Holes* (Fig. 5.90) 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 mm or 2 mm thick (Fig. 5.91). One surface of the material is studded with numerous outcroppings as seen on the scanning electron microscopic view that are approximately 400 microns 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

Fig. 5.88 DualMesh

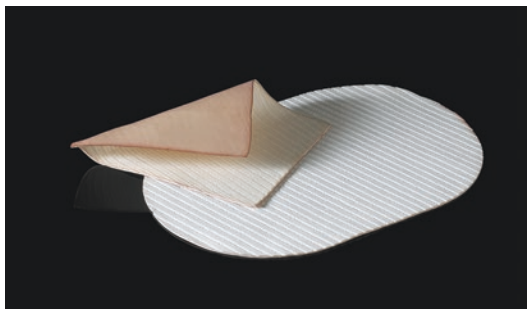

Fig. 5.89 DualMesh PLUS

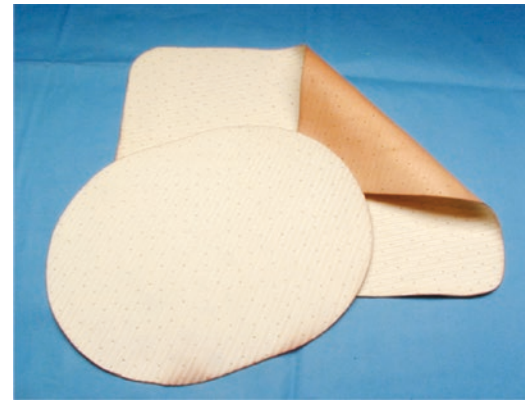

Fig. 5.90 DualMesh PLUS with holes

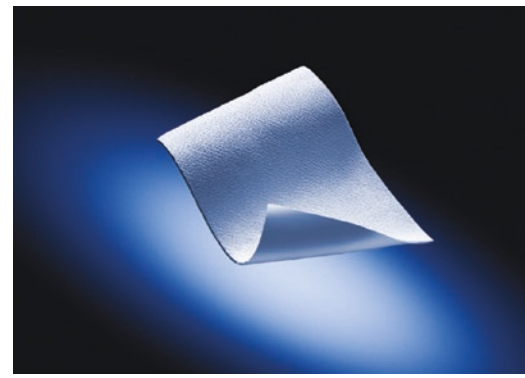

Fig. 5.91 Dulex

Fig. 5.92 MycroMesh

Fig. 5.93 MycroMesh PLUS

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 three microns and the other of 17–22 μm (Fig. 5.92). The latter surface is textured. Although only 1 mm, this material is perforated for reasons similar to that of the DualMesh Plus with holes. *MycroMesh PLUS* is impregnated with the antimicrobials silver and chlorhexidine (Fig. 5.93). Neither of these products is designed for intraperitoneal placement.

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. 5.94) [4]. The variety of available configurations of this product has increased over

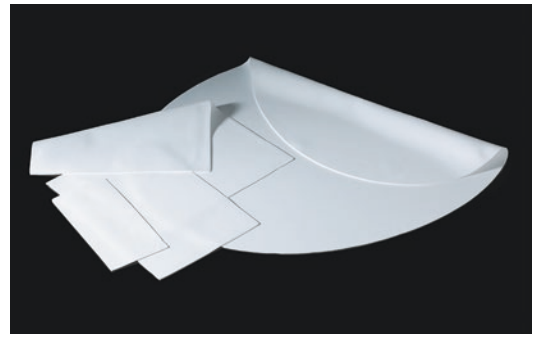

Fig. 5.94 Soft tissue patch

Table 5.12 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, Bayreuth, Germany

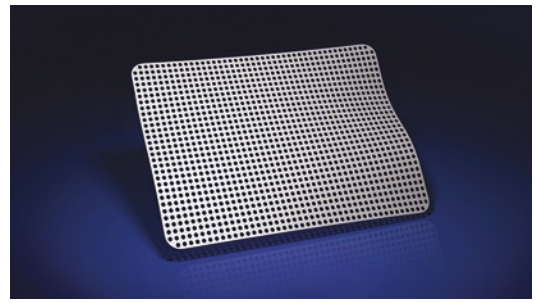

Fig. 5.95 InoMesh

the last several years. Its use, however, has waned because of the development of the other products that are listed in Table 5.11. 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 5.12). For instance, *Inomesh* is a product made of PVDF with laser cut holes (Fig. 5.95). *MotifMESH* and *Omyra* are identical in design and concept

(Figs. 5.96 and 5.97). There 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 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. 5.98). *TiO_2Mesh* is a titanized PP is that of (Fig. 5.99). 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.

This chapter would be remiss if it did not include the use of mosquito netting that has been used in 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 [9, 10]. In fact, recent evidence has shown there is little difference in adverse events with this or the traditional commercial mesh products [11]. This is added to this chapter because of the possibility that it might be used for some type of incisional hernia repair in the future.

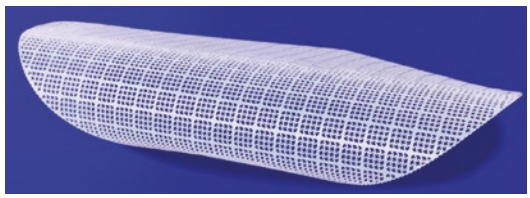

Fig. 5.96 MotifMESH

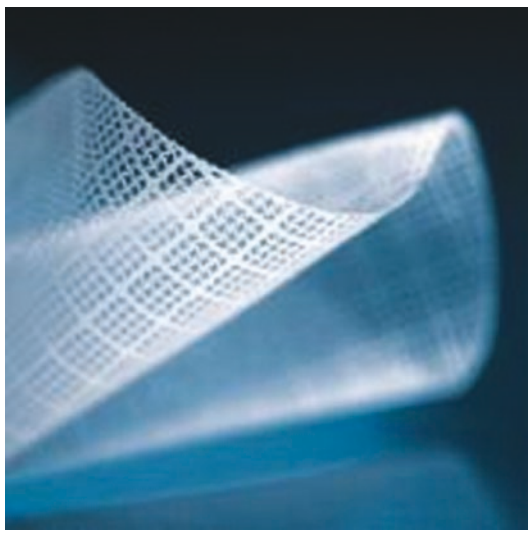

Fig. 5.97 Omyra mesh

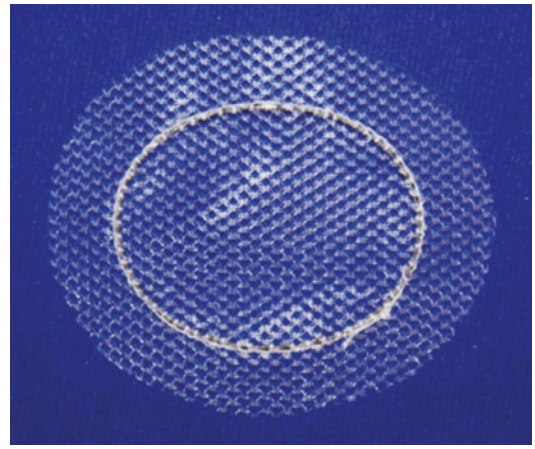

Fig. 5.98 Rebound HRD V

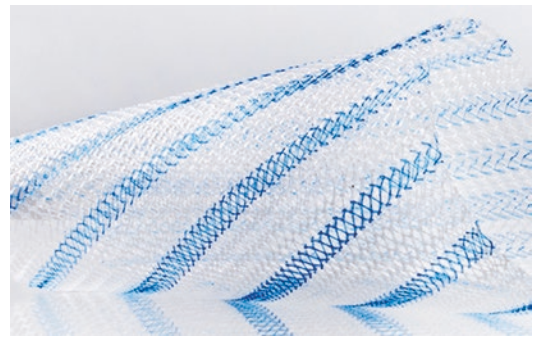

Fig. 5.99 TiO_2 mesh

Combination Flat Synthetic Prosthetics

This grouping of these products is made because there is a permanent portion of these materials and an absorbable component incorporated into

the product that is not meant to be a barrier coating. These prostheses are generally not meant to contact any viscera and do not possess a specific shape (Table 5.13).

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. 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 (Fig. 5.100). The latter two products have absorbable polylactic acid microgrips on one surface. *Parietex ProGrip Laparoscopic* is a flat sheet of polyester that also has microgrips of polylactic acid that last >18 months (Fig. 5.101). It differs from the other ProGrip products in that it has a green portion to aid in orientation of the mesh. There is a light coating of collagen which lessens the "grip' strength to make manipulation during laparoscopic use easier.

Easy Prosthesis Partially Absorbable is a partially absorbable product (Fig. 5.102). It is a combination of PP and poly(glycolide-co-caprolactone) [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. The *4D Ventral* is a flat sheet and differs from the 4D mesh in that it is 40% PP and 60% PLLA (Fig. 5.103).

Table 5.13 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 Ventral, Cousin Biotech, Wervicq-Sud, France
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
Ultrapro, Ethicon, Inc., Somerville, NJ, USA
Ultrapro Advanced, Ethicon, Inc., Somerville, NJ, USA

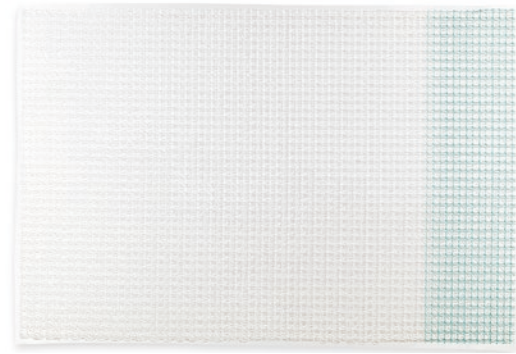

Fig. 5.101 Parietex ProGrip laparoscopic (All rights reserved. Used with permission of Medtronic.)

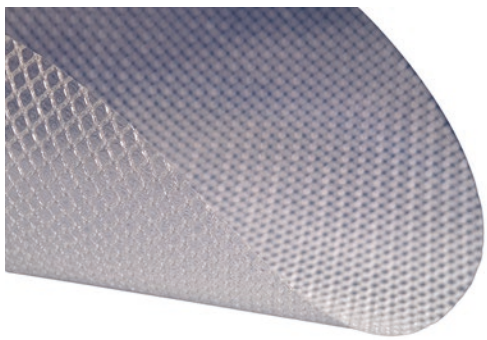

Fig. 5.100 Adhesix

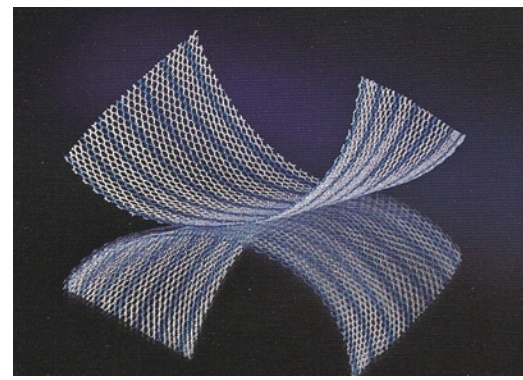

Fig. 5.102 Easy Prothes partially absorbable

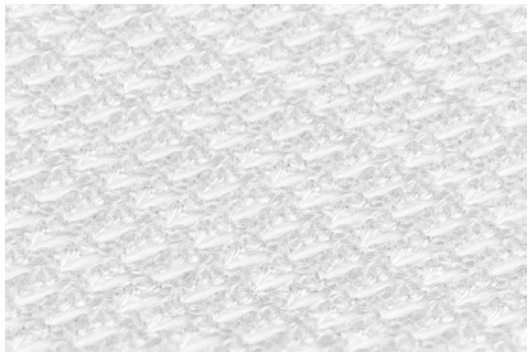

Fig. 5.103 4D Ventral

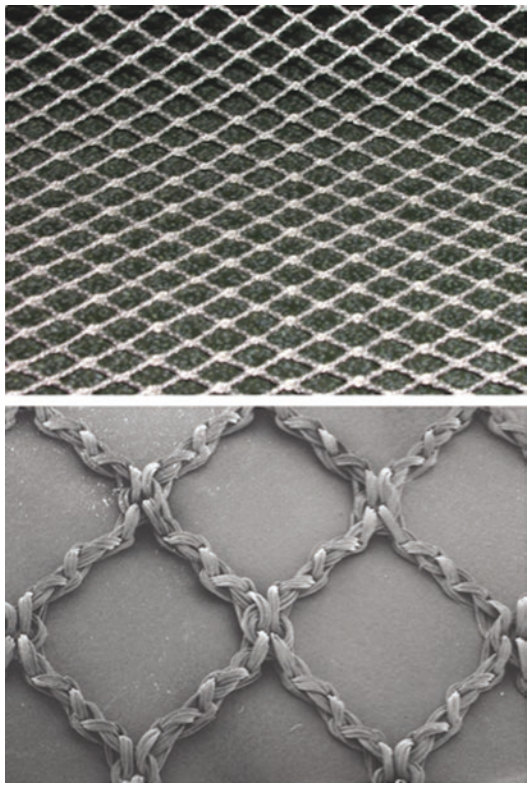

Fig. 5.104 Vypro (Image courtesy of Ethicon, Inc.)

TiMESH has been previously described above and is one of the few products in this section that can be placed against the viscera (Figs. 5.69 and 5.70). *Vypro is* actually a combination of PP and the absorbable polymer polyglactin (Fig. 5.104). The combination of these materials results in a very pliable and malleable material that should only be used in the preperitoneal position. Once the polyglactin has been absorbed, the PP that remains has very large interstices into which the fibroblasts and collagen are deposited. The aim of this product 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 nonabsorbable lightweight PP (Fig. 5.105). 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 stretch (Fig. 5.106). It stretches to the greatest degree perpendicular to the blue stripes.

Prostheses with an Absorbable Barrier Component

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

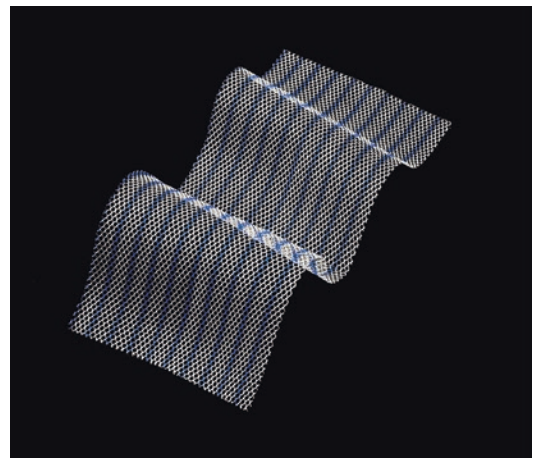

Fig. 5.105 Ultrapro flat mesh (Image courtesy of Ethicon, Inc.)

Fig. 5.106 Ultrapro Advanced (Image courtesy of Ethicon, Inc.)

Table 5.14 Combination prostheses with an absorbable barrier

Adhesix, Davol, Inc., Warwick, RI, USA
C-QUR Mosiac, Getinge Group, Wayne, NJ, USA
Easy Pro Composite Mesh, TransEasy Medical Tech. Co.Ltd., Beijing, China
Parietene Composite, Medtronic, Minneapolis, MN, USA
Parietex Optimized Composite (PCO$_x$), Medtronic, Minneapolis, MN, USA
Parietene DS, Medtronic, Minneapolis, MN, USA
Parietene ProGrip, Medtronic, Minneapolis, MN, USA
Parietex ProGrip, Medtronic, Minneapolis, MN, USA
Proceed, 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

processes. These are generally referred to as "tissue-separating" meshes as they create an absorbable barrier between the permanent product and the viscera (Table 5.14). 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.

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 postimplantation. 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 regarding adhesion development. There have been some central failures due to materials that were too lightweight and/or macroporous are no longer available.

Adhesix 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 (Fig. 5.100). *C-QUR Mosiac* is made of a lightweight Prolite mesh onto which Omega-3 Fatty Acid (O3FA) has been coated onto the product (Fig. 5.107). 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. *Easy Pro Composite Mesh* is constructed of lightweight PPM with a barrier coating of poly-lactide-co-caprolactone (Fig. 5.108). It is indicated for intraperitoneal usage. It has an "F" on the visceral surface to identify the orientation toward the intestine.

Parietene Composite is PP coated with the hydrophilic collagen and other substances that are

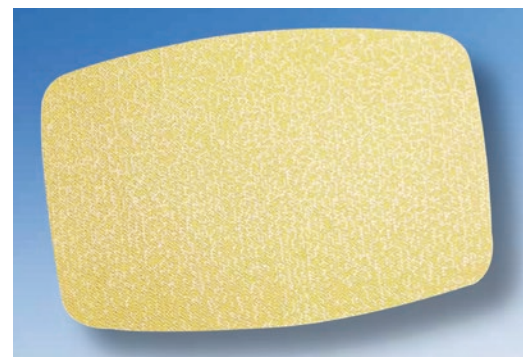

Fig. 5.107 C-Qur Mosaic

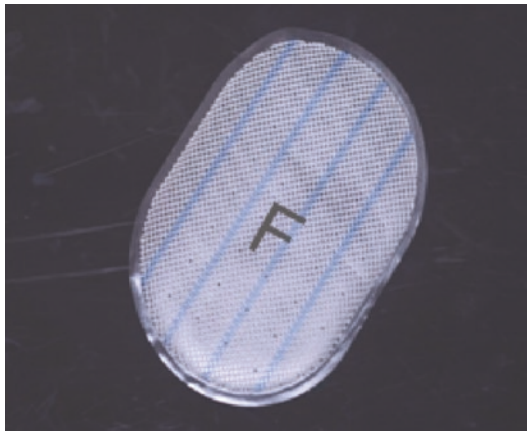

Fig. 5.108 EasyPro composite

Fig. 5.109 Parietex Optimized Composite (PCOx) (All rights reserved. Used with permission of Medtronic.)

used in the better-known Parietex Composite discussed below. It has an incorporated hydrophilic layer of a mixture of oxidized Type I atelocollagen, polyethylene glycol, and glycerol, which is absorbable. *Parietex Optimized Composite (PCOx)* is a POL biomaterial that also has this barrier coating (Fig. 5.109). It can be purchased with the *AccuMesh Positioning System* (Fig. 5.110). *Parietene DS* is a dual-sided product that has Paritene macroporous PP that is coated on one side with glycolide, caprolactone, trimethylene carbonate, and lactose. This barrier coating is essentially degraded within 105 days. There is a violet marking to help position the mesh. There are two preplaced sutures made of a stereoisomer of PP and polyethylene that are needed to differentiate the sides of the product and to be used for transparietal fixation. *Parietene ProGrip* and *Parietex ProGrip* also differ in that the former is of PP and the latter is of POL. Both have the polylactic acid grippers (described earlier in this chapter) so that they potentially do not need fixation. The coating on these products is very minimal, so it is not recommended that these products should contact the viscera.

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. 5.111). The fabric acts as a barrier to separate the PP from the tissue. The ORC is absorbed within 4 weeks. 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."

SepraMesh IP is a single layer of heavy weight polypropylene and is covered by barrier that is a combination of carboxymethylcellulose and hyaluronic acid (Fig. 5.112). It is bound together with

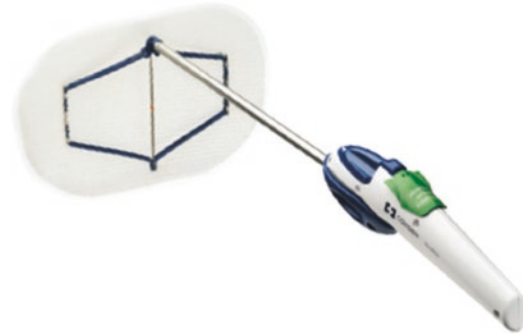

Fig. 5.110 AccuMesh positioning system (All rights reserved. Used with permission of Medtronic.)

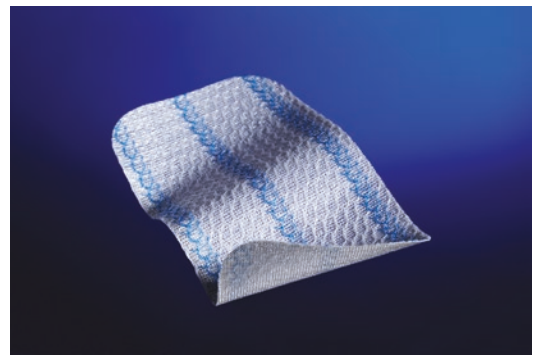

Fig. 5.111 Proceed (Image courtesy of Ethicon, Inc.)

polyglycolic acid fibers and a hydrogel. This product requires brief immersion into saline solution prior to its use to activate the gel. The 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. 5.113). The "Sepra" technology has been extended to the original Ventralex and Ventrio products (Table 5.15). 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. 5.114

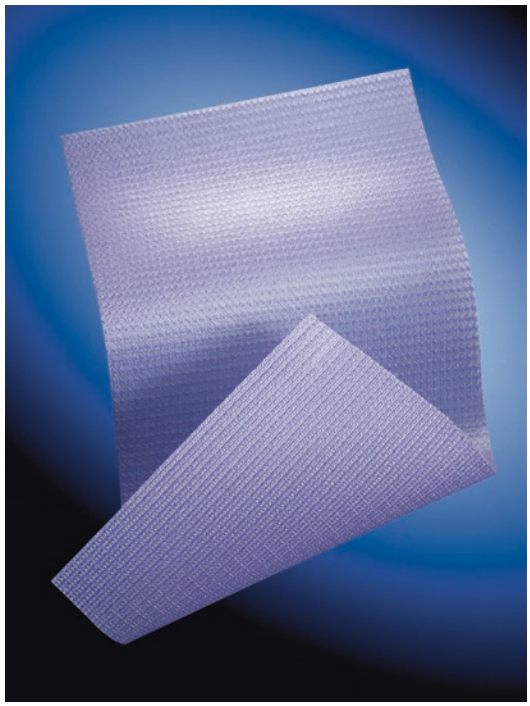

Fig. 5.112 SepraMesh IP

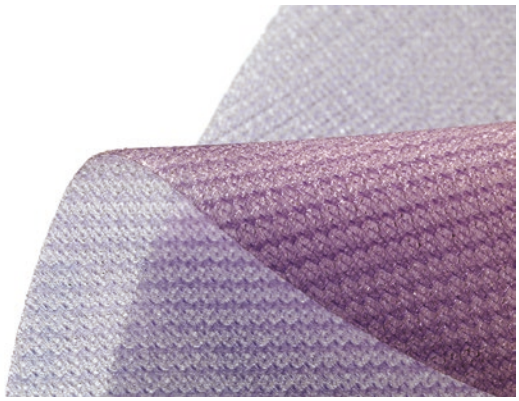

Fig. 5.113 Ventralight ST

Table 5.15 Combination prostheses with a permanent barrier

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

Fig. 5.114 Ventralex ST

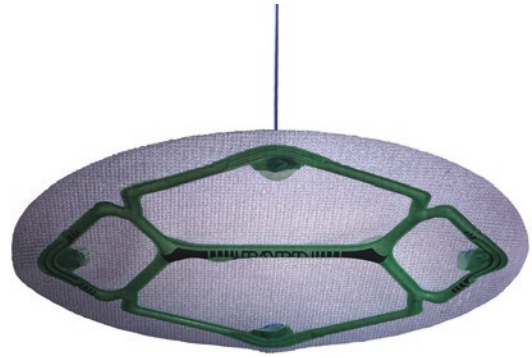

Fig. 5.116 Ventralight ST with Echo PS

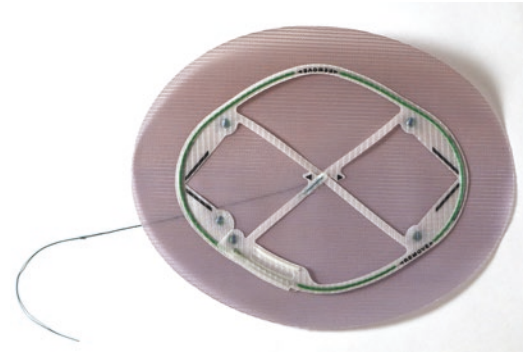

Fig. 5.117 Ventralight ST with Echo 2

Fig. 5.115 Ventrio ST

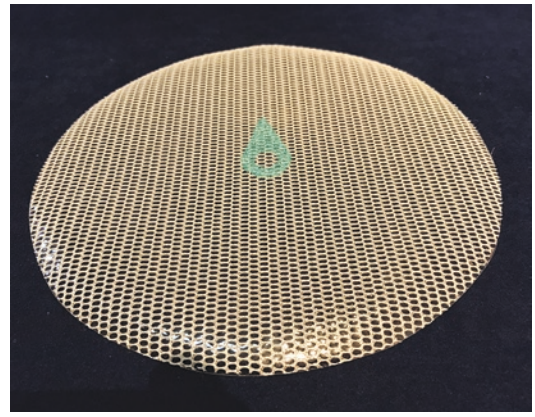

Fig. 5.118 Symbotex (All rights reserved. Used with permission of Medtronic.)

and 5.115). While the former product was originally designed for use in open repair, it has found use in the laparoscopic repair of smaller ventral and incisional hernias. *Ventralex ST* is also available with the *ECHO PS*, which is a positioning aid (Fig. 5.116). It is a balloon that is inflated to stiffen the material that effectively makes fixation much easier. There will be an improved version that is able to stiffen the product with nitinol wire (rather than the balloon) and uses a central hoisting suture rather than the tubing to inflate a balloon (Fig. 5.117). *Symbotex* is a polyester material that is lighter in weight than the Parietex PCO_x (Fig. 5.118). It has the same barrier material as the PCO_x product described above (i.e., Type I atelocollagen, polyethylene glycol, and glycerol). The green marker is 2D polyester.

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 5.15). The method of fixation of these different materials differs for 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 5.11 and 5.12). What is consistent in all of the prostheses is the presence of a permanent barrier to resist adhesion formation while allowing for ingrowth on the parietal side of these meshes to repair a hernia effectively.

CO3+ has been described in the flat mesh section (Fig. 5.80). It is a combination of POL and PUR with grips. *ClearMesh Composite (CMC)* is a pure PP mesh (Fig. 5.119). There is a textured side that is composed of a single filament macroporous weave and a nonadhesive side that is composed of a nonporous 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. 5.120). It has sewn seams that can be used to cut the mesh to conform to the needs of the hernia treated. *Combi Mesh Plus* is a combination of PP and polyurethrane to allow usage intrabdominally (Fig. 5.121). There is an attached suture to delineate the parietal surface. The polyurethane layer faces the viscera. *Composix E/X Mesh* is flat Bard mesh on one side and ePTFE on the other side (Fig. 5.122). 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

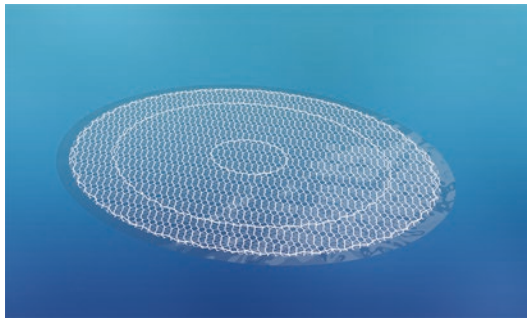

Fig. 5.119 ClearMesh composite

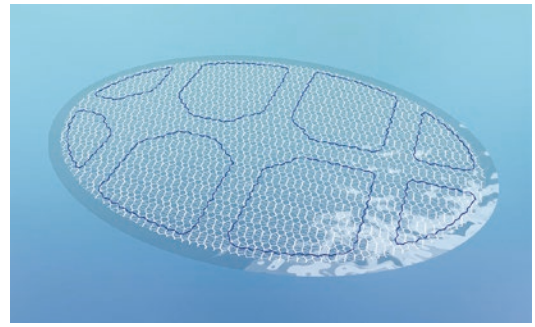

Fig. 5.120 Plurimesh

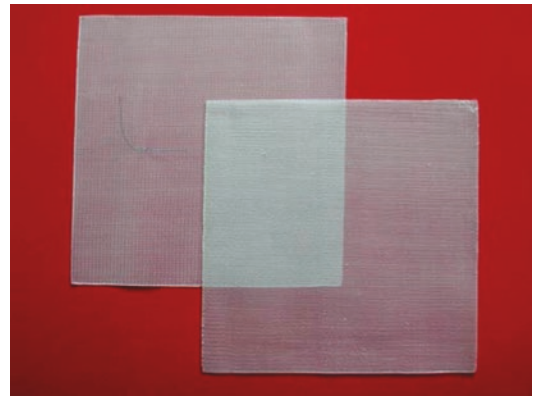

Fig. 5.121 Combi Mesh Plus

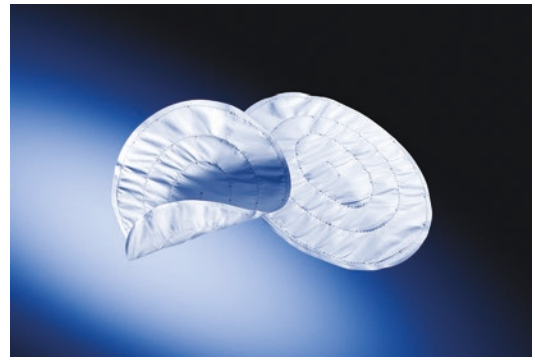

Fig. 5.122 Composix E/X

very similar to the Composix E/X except that the former uses the lighter Bard Soft Mesh rather than the Bard mesh (Fig. 5.123). 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. 5.124). 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.

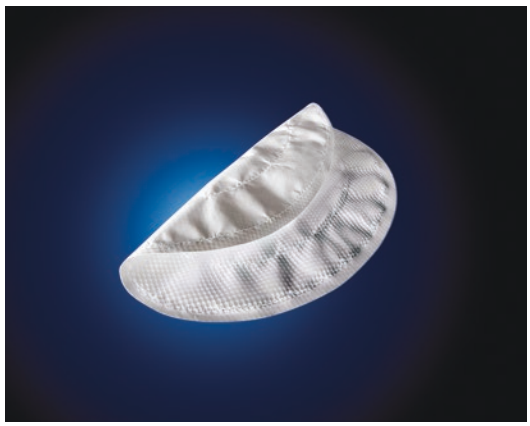

Fig. 5.123 Composix L/P

Fig. 5.124 Composix L/P mesh with Echo PS

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. 5.125). This version is intertwined with monofilament polyvinylidene fluoride (PVDF) on one surface. 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 another layer of silicone on the other as a tissue-separating material (Fig. 5.126). 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. 5.127). It is the only material that possesses lines on the product to delineate the midportions of each side to ease positioning. 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

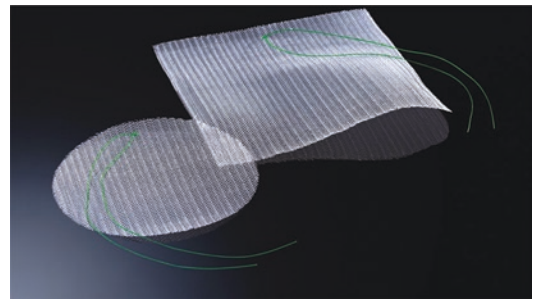

Fig. 5.125 DynaMesh IPOM

Fig. 5.126 IntraMesh

part of the Intra-Swing composite family, which is a macroperforated three-dimensional POL that has a coating of tissue-separating PUR on one surface (Fig. 5.128). 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 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. 5.129). 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. 5.98). It is designed for use in the preperitoneal space. *RELIMESH* is another product that incorporates the PP on one surface and ePTFE on the other to allow placement against the viscera (Fig. 5.130). 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

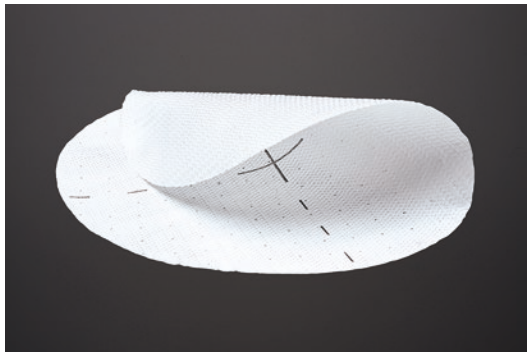

Fig. 5.127 IntraMesh T1

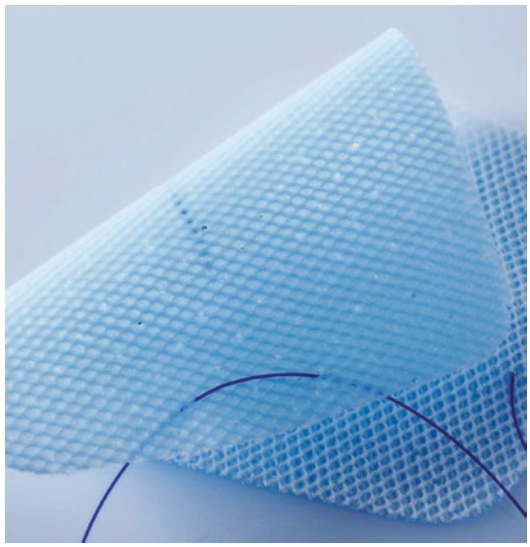

Fig. 5.128 IS 180

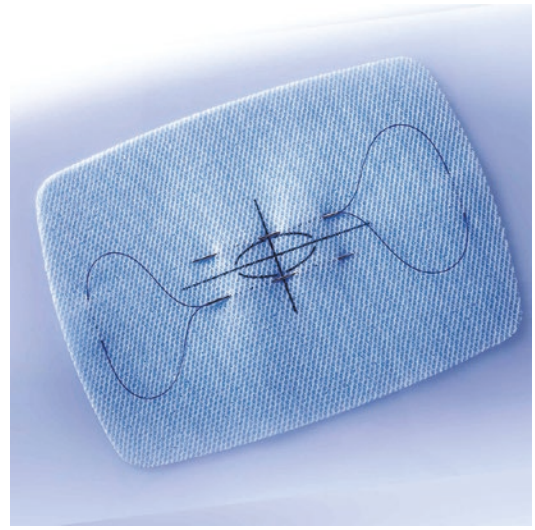

Fig. 5.129 Prefix

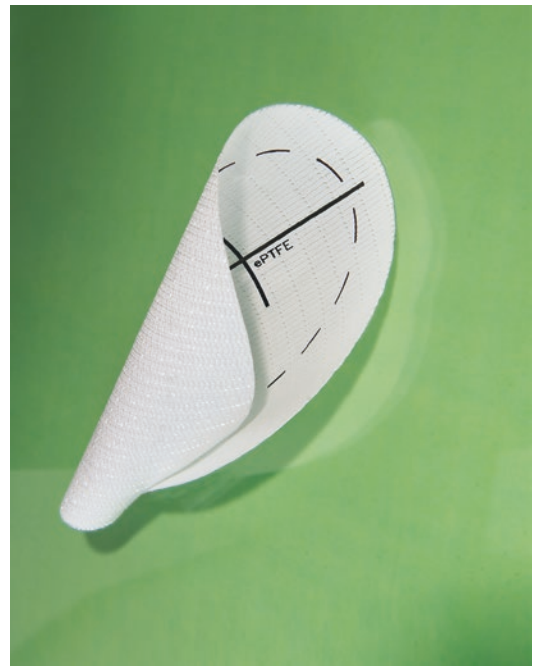

Fig. 5.130 RELIMESH

marked to aid in positioning and fixation. *SMH2+* is PP and PUR and is available for ventral and incisional hernia repair even though the shape in the figure is rather rounded (Fig. 5.131). *SM3+* has been described in the flat mesh section of the chapter and has also been noted in other sections (Fig. 5.86). It is made of polyester and impregnated polyurethane and can be used in open or laparoscopic methods.

SurgiMesh XB has a nonwoven, non-knitted structure as does the SurgiMesh WN described earlier (Fig. 5.132). 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). *TiMesh* is the same material that has been described in several locations within this chapter (Fig. 5.70). The titanized PPM can be used in the intraperitoneal location (per the manufacturer). Another titanized PPM is that of *TiO_2Mesh* (Fig. 5.99). This is described in the Miscellaneous Flat Mesh section above.

Ventralex is a self-expanding PP device (because of the outer ring of PDO) that has ePTFE on one side to allow placement adjacent to viscera (Fig. 5.133). 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. 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. 5.134). Within the PP surface there are

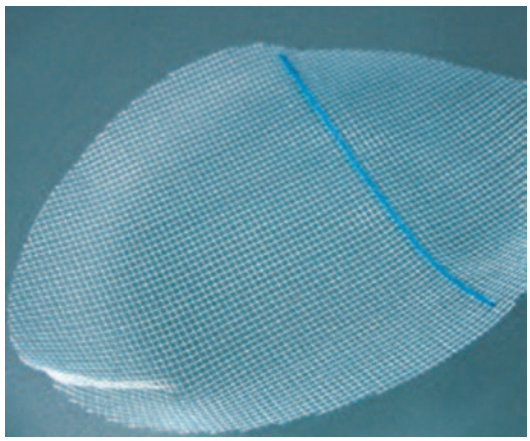

Fig. 5.131 SMH2+

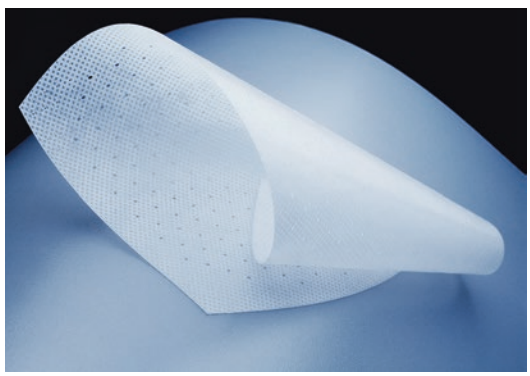

Fig. 5.132 Surgimesh XB

Fig. 5.133 Ventralex

Fig. 5.134 Ventrio Hernia Patch

"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.

Stomal Products

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 the result is 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. Many of these options involve the use of one of the biologic, synthetic absorbable or permanent products described earlier in this chapter. These will not be rediscussed. As with many of the other products in this chapter, these can generally be used with the open or laparoscopic technique. The materials listed in Table 5.16 are specifically designed for stomal hernia repair.

Colostomy Mesh is a single layer PP product (Fig. 5.135). 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. 5.136). 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 with an available opening of 3.5 cm or 5.0 cm (Fig. 5.137). It is also supplied without a hole and can be configured as required (Fig. 5.138). *Polyvalent Clear Mesh Composite (PCMC)* has already been described for incisional and ventral hernia repair. It can also be used for parastomal hernia repair

Table 5.16 Stomal prostheses

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

Fig. 5.135 Colostomy mesh

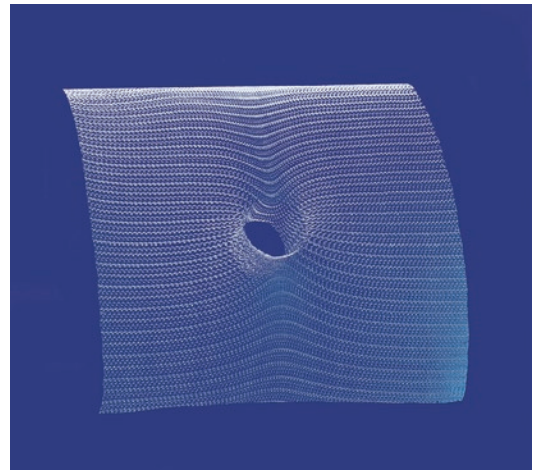

Fig. 5.136 DynaMesh IPST

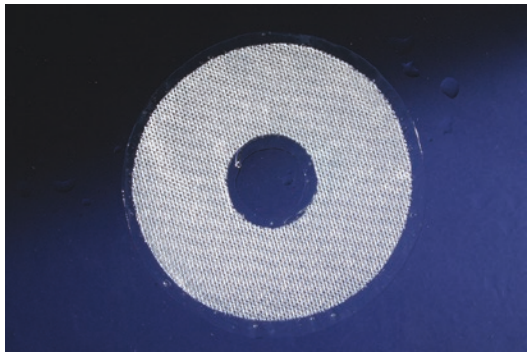

Fig. 5.137 Parietex Parastomal with hole (All rights reserved. Used with permission of Medtronic.)

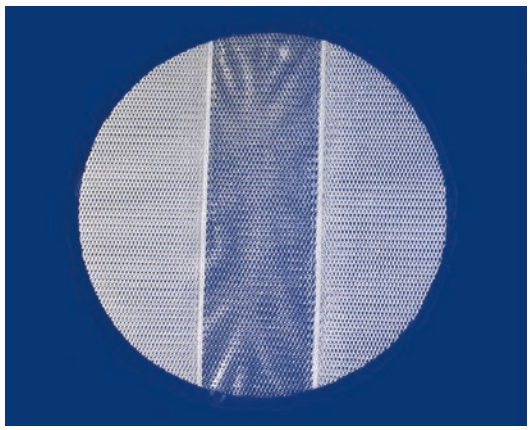

Fig. 5.138 Parietex Parastomal without hole (All rights reserved. Used with permission of Medtronic.)

(Fig. 5.120). It is supplied in such a manner that it can be cut to confirm to whatever the size the surgeon chooses.

TiLENE Guard is of titanized PP (Fig. 5.139). 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.

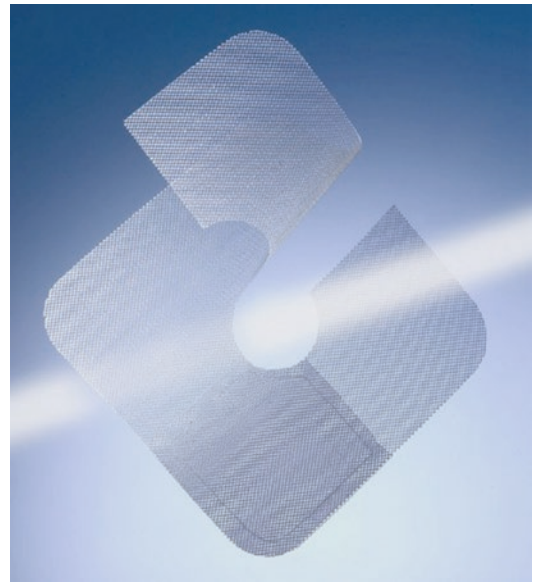

Fig. 5.139 TiLENE guard

Table 5.17 Fixation devices for hernia repair (an asterick indicates absorbable fasteners)

*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
Tacker, Medtronic Minneapolis, MN, USA
TiTack, TransEasy Medical Tech.Co.Ltd., Beijing, China

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 the most popular. Currently, there are a variety of these devices that one may choose to fixate the meshes placed in hernia repair (Table 5.17). Surgeon preference, mesh selection, and whether permanent or absorbable fixation is

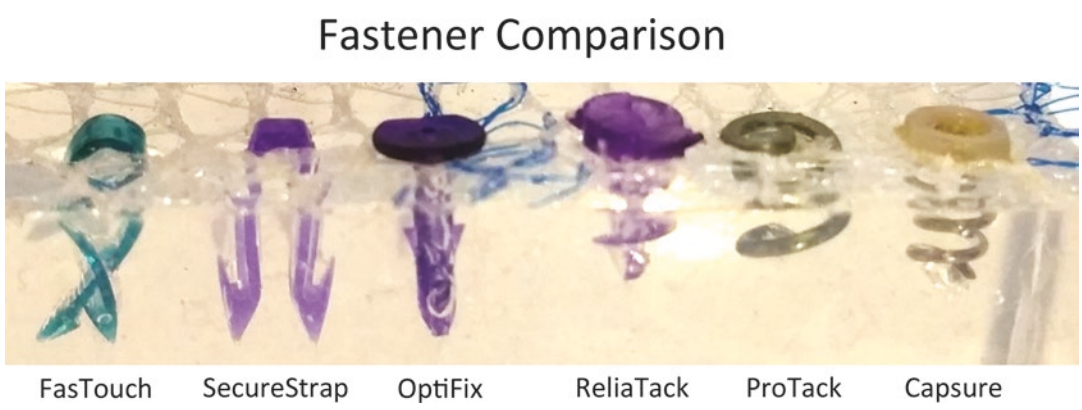

Fig. 5.140 Tack comparison

Fig. 5.141 Absorbatack (All rights reserved. Used with permission of Medtronic.)

Fig. 5.142 CapSure

needed will dictate the product decision. One should consider the configuration of the head of these fasteners and 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 (Fig. 5.140). 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 information.

AbsorbaTack is a 5 mm fixation device and provides an absorbable synthetic polyester copolymer screw-like fastener derived from PGLA (Fig. 5.141). The fastener itself measures 5.1 mm in length. The laparoscopic version is available 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 316L stainless steel (Fig. 5.142). The *DegraTack* is an absorbable screw-like tack and is also made of polylactide-co-glycolide (PGLA), which is totally degraded in 12 months (Fig. 5.143). The iMesh tack is another PGLA device (Fig. 5.144). It has 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 that does not employ any of the screw-like fasteners listed in this section but instead delivers a suture-like closed "locked" loop (Figs. 5.145 and 5.146). It can be reloaded with either a 10 or 25 reload. Its

Fig. 5.143 DegraTack

Fig. 5.144 iMesh tacker

Fig. 5.145 FasTouch

Fig. 5.146 FasTouch fastener

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 soon. The *Endo Universal Stapler* is to be used via a 10 or 12 mm trocar (Fig. 5.147, middle). It can be rotated 360° and articulated up to 65%. Consequently, this device can be used in four different positions. The *MultiFire Endo Hernia Stapler* is introduced through a 12-mm trocar (Fig. 5.147, upper). Both of these devices fire "box-shaped" titanium staples that will fixate the prosthesis into which it is fired. They are both reloadable with either 4.0 mm or 4.8 mm staples (Fig. 5.147, 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

Fig. 5.147 Multifire and Endo universal staplers (All rights reserved. Used with permission of Medtronic.)

usage during open hernia repair (Fig. 5.148). 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 T.

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. 5.149). 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. 5.150). Both of these fasteners are available in either 15 or 30 devices delivered via a 5 mm product. Permafix is made of a gray molded permanent (nonabsorbable) polymer. SorbaFix is made of the same purple absorbable material as OptiFix.

The *ProTack* is one of the older products that delivers a permanent titanium helical fastener by a 5 mm device (Fig. 5.151). 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 Absorbatack (Fig. 5.152). It can be

Fig. 5.148 MultiFire VersaTack (All rights reserved. Used with permission of Medtronic.)

Fig. 5.149 Optifix

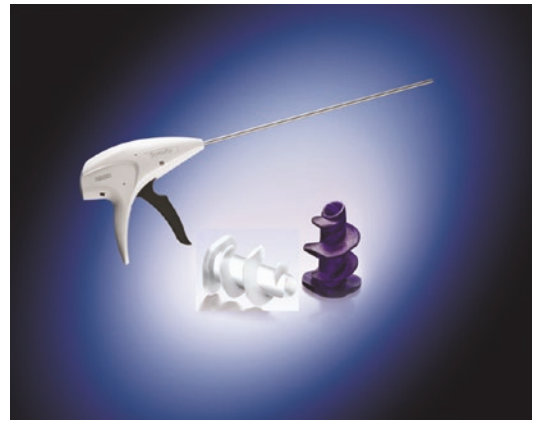

Fig. 5.150 Sorbafix and Permafix

Fig. 5.151 ProTack (All rights reserved. Used with permission of Medtronic.)

Fig. 5.152 Reliatack (All rights reserved. Used with permission of Medtronic.)

reloaded with a cartridge that contains either 5 or 10 fasteners. It is supplied with either a standard 5.1 mm device or a deep tack that is 7.0 mm in length (Fig. 5.153). It is the only fastener that is available with two different tack lengths.

The *SECURESTRAP* is pre-loaded with *25* absorbable straps (Fig. 5.154). The straps are composed of a blend of polydioxanone and L(−)-lactide and glycolide dyed with D&C Violet No. 2. This product has two legs similar to the staplers and does not screw into the tissues. The ends of these straps are barbed to aid in fixation. The width between the points is 3.5 mm. The entire devices length is 6.7 mm but the distance

Fig. 5.153 ReliaTack standard or deep purchase tack (All rights reserved. Used with permission of Medtronic.)

Fig. 5.154 Securestrap (Image courtesy of Ethicon, Inc.)

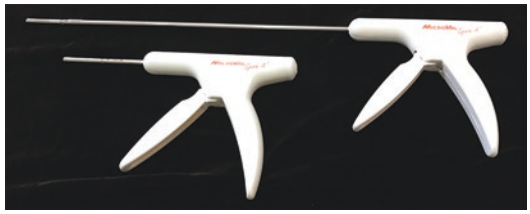

Fig. 5.155 Spire' it

from the inner portion of the strap to the point of fixation of the strap is 4.9 mm (i.e. the "grip"). *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. 5.155). There are two turns of the ring with a final form of 4 mm. It is reloadable and is available in a 30 cm length for laparoscopic surgical applications.

The *Tacker* delivers helical titanium tacks virtually identical to the ProTack (Fig. 5.157). The *Tacker* delivers 30 tacks in the single-use device. There is an available multiuse 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. 5.157 and 5.158).

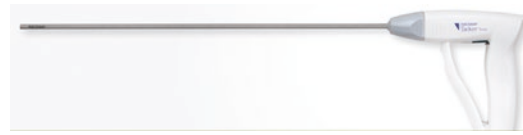

Fig. 5.156 Tacker (All rights reserved. Used with permission of Medtronic.)

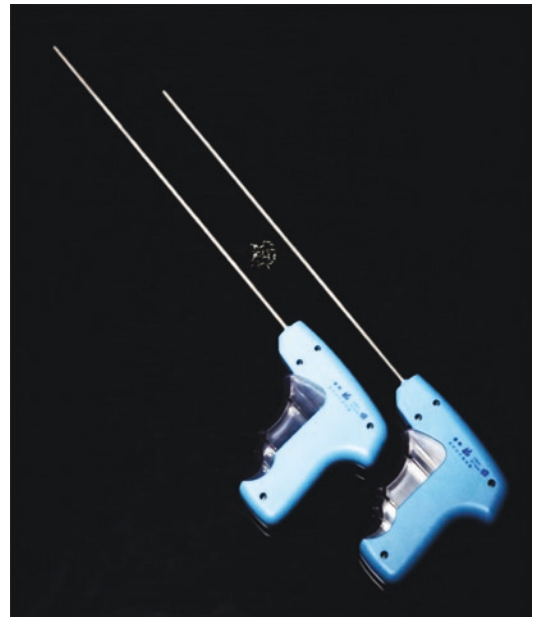

Fig. 5.157 TiTack

Fig. 5.158 TiTack tacks

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 we could make this at this time. Undoubtedly by the time of the printing of this textbook other products 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.

Acknowledgements Although it is not designated on the propriety names of any 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.

Many of these photos were taken by myself or provided by the company itself. I wish to thank all of these companies for their permissions and invaluable assistance in putting the most accurate information into this chapter that I could not have obtained without their assistance.

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