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TENSION-FREE, SUTURELESS, PRESHAPED MESH HERNIOPLASTY

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Over the years, various surgical techniques, with or without prosthesis, have been utilized in inguinal hernia repairs. After Lichtenstein introduced the concept of a tension-free repair in 1986 (2), this became the procedure of choice. We began using a tension-free sutureless repair with a preshaped mesh in 1989.

From 1989 to 1997, all primary inguinal hernioplasties at the Trabucco Hernia Institute, of which there were 3,422, were performed using this technique (7). A preshaped mesh alone or in conjunction with a three-dimensional plug was used. The plug was formed by folding a circular mesh into the shape of a dart. This was then inserted into the deep ring of indirect inguinal hernias after the reduction of the sac.

From 1997 to 1999, 275 herniorrhaphies were performed. During this period, the use of the three-dimensional plug was abandoned. Flat sheaths of mesh, which were slit to accommodate cord structures, were implanted (8), or suture narrowing of the deep inguinal ring in small indirect hernias was used instead. A sutureless preshaped onlay mesh was implanted routinely in both groups of patients.

The principles of the sutureless preshaped mesh hernioplasty are based on the following observations:

1. There is an anatomically closed space in the inguinal canal below the external oblique aponeurosis-a sub-aponeurotic space, which we have come to refer to as the "inguinal box" (Fig. 15.1) (8). It had been observed that the size and shape of this space has minimal variations from one individual to another.
2. It is possible to design and utilize a preshaped mesh in all primary inguinal repairs. In other words, a universal preshaped-size mesh that will virtually always fit into the subaponeurotic inguinal space of every individual (Fig. 15.2) (7, 8).
3. In order for a sutureless preshaped mesh to be effective, it must be rigid in consistency and possess a controlled memory (remain flat without a tendency to wrinkle or curl) (6).

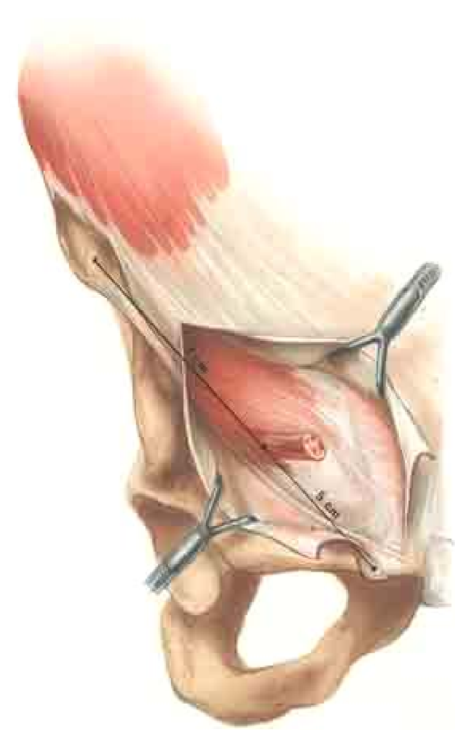

FIGURE 15.1. The open "inguinal box."

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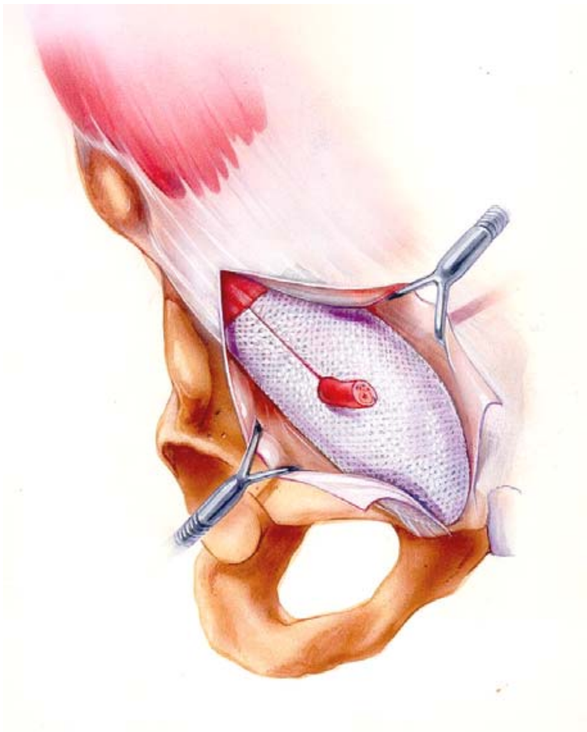

FIGURE 15.2. The sutureless preshaped mesh in the closed anatomic space of the inguinal box; cannot move.

SUBAPONEUROTIC INGUINAL SPACE

Its upper boundary is sealed by the insertion of the external oblique aponeurosis on the anterior rectus sheath. Its lower border ends in the concavity of the shelving edge of Poupart's ligament. The medial boundary is formed by the pubic tubercle and the lateral boundary by the blunt dissection of the subaponeurotic space, which usually ends 3.5 cm medial to the anterosuperior iliac spine. The bottom of this space is the floor of the inguinal canal, and the external oblique aponeurosis is the top of the space.

This anatomically closed space was measured during 800 hernioplasties (4-7). The average measurements were as follows:

12 cm from the anterosuperior iliac spine to the pubic tubercle, 7 cm from the anterosuperior iliac spine to the deep inguinal ring, 5 cm from the internal inguinal ring to the pubic tubercle, and 5 cm from the insertion of the external oblique muscle on the anterior sheath of the rectus muscle to the shelving edges of Poupart's ligament. The pre-shaped mesh was designed to fit a closed space with these measurements.

THE PRESHAPED MESH (USED AS AN ONLAY FOR THE INGUINAL CANAL)

This is made of monofilament polypropylene weaved into a mesh structure. The mesh is then treated with a combination of heat and traction in order to tighten the weave and flatten the mesh. This process allows the mesh to lose part of its memory (controlled memory) (6,7) and acquire a flat shape, thus losing its tendency to curl or wrinkle. The dimensions of the preshaped mesh are based on the average size and shape of the subaponeurotic inguinal space, which is 10 ± 4.5 cm. The mesh has a 1.2-cm in diameter circular opening for the exit of the spermatic cord. This opening is located 6 cm from the tip and 4 cm from the base of the mesh.

RIGIDITY OF THE MESH

Soft meshes placed on the floor of the inguinal canal without sutures will have a tendency to wrinkle or curl, thus increasing the potential for the formation of dead spaces and recurrences (6). Soft meshes such as Marlex (C.R. Bard, Inc., Murray Hill, NJ, U.S.A.) and Prolene (Ethicon, Inc., Somerville, NJ, U.S.A.) cannot be implanted without sutures. Curling from memory may also result from the manner in which the mesh is packaged. If the mesh is packaged folded, it will tend to fold and will not lie flat. All polypropylene prostheses have memory, even after sutures are applied.

In a sutureless technique, the mesh must lie flat when implanted and remain flat during the fibroblastic infiltration into its pores, a process that seals the mesh into place.

A rigid preshaped mesh with controlled memory does not need to be sutured when placed in a closed space. It-implanted correctly, it will always lie flat and will nor move or form dead space. Such a mesh is time saving and easy to implant. The postoperative discomfort is minimal and nerve injury rare. The prosthesis does not need to be shaped by hand at the time of surgery or fixed by sutures. Contamination due to handling or trimming a flat sheer of-mesh is avoided, as well as tissue trauma produced by sutures. Most importantly, a sutureless prosthesis is always tension free and is not subject to tension along the suture line. Curling or wrinkling of a rigid mesh has never been observed.

SUTURELESS PROSTHESIS

A preshaped mesh of Marlex was first used in 1988. Later, this mesh was found to curl or wrinkle under the fascia, due to its soft consistency and presence of memory. The use of a double-layer preshaped mesh, a more rigid prosthesis, was proposed in 1990 (4). This preshaped mesh was made by placing two single sheets of Marlex (7), one on top of the other, and cutting them using an electric soldering rip. This double-layer mesh was found to have the desired rigidity and became very popular in Italy. The problem was that this preshaped mesh was nor commercially available. Surgeons were forced to fabricate the meshes by themselves and to use illegal sterilization methods, which lack quality control. The U.S. Food and Drug Administration and C.E. (European Community) allow only approved industrial Sterilization plants to sterilize medical devices. Both agencies have strict rules for quality control.

In the search for a single-layer mesh with the ideal rigidity and characteristics, 12 new single-layer polypropylene preshaped prostheses were fabricated and implanted in 36 patients undergoing inguinal hernioplasties in 1995 and 1996. Every type of mesh was implanted in three of these patients.

The prosthesis was made using monofilament polypropylene of 180 ~m in diameter. A monofilament of 160 ~m in diameter is used in soft meshes such as Marlex and Prolene. Each of the 12 meshes had a different knit structure. This accounted for differences in weight, thickness, and porosity. The traction and heat treatment the meshes were subjected to after weaving accounts for the "controlled memory."

The weight of each prosthesis was calculated in grams per square meter. Weights ranged from 90 to 240 g/m2. The heavier the mesh, the greater the thickness and rigidity, and the lower the porosity. All meshes were observed during surgery for their ability to lie flat without wrinkling or curling.

The ideal prosthesis was chosen on the basis of the following:

1. Weight-Lower weights were preferred
2. Thickness-thinner meshes were preferred
3. Porosity-a greater porosity was preferred
4. Rigidity
5. Absence of memory
6. Tendency to remain flat after implant

Naturally, the final choice was a compromise. Nine of the meshes were discarded because of their tendency to curl when implanted without sutures. Their weights ranged from 90 to 168 g/m2. The mesh ot-240 g/m2 was eliminated because it was too thick and its porosity too low. Two of the 12 meshes were eventually selected as being ideal for J sutureless technique. They were Hertra-R (rigid), of 223 g/m2, and Hertra-s (semirigid), of 177 g/m2. The Hertra preshaped prosthesis (7) always remained flat when implanted on the floor of the inguinal canal and was found not to shrink after implantation (3). It has been reported that other soft polypropylene meshes may shrink up to 20% (1). If a sutureless mesh shrinks, it may increase the risk of recurrence. The Hertra-s was used in individuals of normal weight and the Hertra-R in obese patients (Table 15.1).

CIRCULAR MESH FOR THE PREPERITONEAL SPACE

Primary inguinal hernias are flat defects of the thin transversalis fascia. They have no real depth. The use of a flat mesh should therefore be preferred to the use of a three-dimensional plug. Three-dimensional plug, such as the plug *T2,* is indicated only in repairs of tunnel-type defects such as a femoral or recurrent inguinal hernia (5). A flat mesh is a preperitoneal prosthesis that is placed around the spermatic cord. It is used in conjunction with a preshaped onlay mesh in the repair of medium-to-large indirect primary inguinal hernias (T4), or in large direct hernias with a loss of substance in the posterior wall (T5).

MESH T4 AND TS (HERNIAMESH)

T4 is a 5-cm in diameter round preshaped mesh with a 1-cm eccentric hole. It is positioned around the spermatic cord in the preperitoneal space with the eccentric hole directed toward the iliac vessels, where the free space is limited. The enlarged deep ring is narrowed over the implanted T4. The mechanical containment of this mesh extends over the margins of the defect, unlike the containment of a

TABLE 15.1. CHARACTERISTICS OF PROSTHESES[a]

Mesh	Size of Monofilament	Weave	g/m2	Porosity	Thickness of Mesh
Hertra-R	180 ụm	Two course Tuch mit Shuss	223	65.2%	0.68 mm
Hertra-S	180 ụm	Two course Atlas Tuch	177	63.8%	0.53 mm
Hermesh 3	180 ụm	Single course Atlas Tricot	127	69.7%	0.48 mm
Hermesh 4	180 ụm	Single course Atlas	112	72.4%	0.45 mm
Hermesh 5	180 ụm	Single course Atlas	107	68.3%	0.42 mm

[a]Herniamesh SRL, Via Cire 22/A, San Mauro Torinese, Torino, Italy 10099.

three-dimensional plug, which is limited to the inside of the defect. This mesh does not need suturing because it lies between the closed posterior wall above and the diverging elements of the spermatic cord below.

The mesh T5 is a preshaped mesh that is 5 cm in width and 10 cm in length. It has a 1-cm hole for the spermatic cord to pass through. It is used as a preperitoneal implant that is anchored to a preshaped Hertra mesh. The upper curved border of the mesh T5 reaches over the aponeurotic arch of the transversus muscle and its lower border follows Cooper's ligament. The distance between the hole for the exit of the spermatic cord and its medial aspect is 8 cm.

SUTURELESS PRIMARY INGUINAL HERNIOPLASTY

For the sake of simplicity, indirect hernias are classified as small, medium, or large. The direct hernias are classified as involving part of the posterior wall or all of the wall, and with loss of the posterior wall substance.

Small indirect hernias were repaired by dissection and reduction of the sac into the deep ring, which was then narrowed with sutures. A sutureless Hertra mesh was implanted and the external oblique aponeurosis closed over the mesh and under the spermatic cord.

Medium and large indirect hernias were repaired by dissection and reduction of the sac, followed by implantation of the T4 around the spermatic cord in the preperitoneal space. The posterior wall was closed over the mesh T4. A preshaped Hertra mesh was then implanted on the posterior wall of the inguinal canal. A Foley catheter was sometimes used to facilitate the placement of the mesh T4. The catheter was inserted into the deep inguinal ring and inflated with approximately 30 cc of air. The preperitoneal segment of the spermatic cord was exposed, allowing for an easier placement of the T4. The Foley was deflated and removed (Fig. 15.3).

Direct hernias with partial or total wall involvement were repaired by reduction of the sac with a continuous running suture, which flattened the floor of the inguinal canal, thus allowing for a better apposition with a preshaped Hertra mesh.

Direct hernias with loss of substance of the posterior wall were repaired using two anchored prostheses, a T5 and a Hertra. The posterior wall was opened and the preperitoneal fat dissected and retracted.

A Reverdin's needle carrying a suture material was introduced into the soft tissue near the pubic tubercle, directed toward the dissected preperitoneal space near the lacunar ligament. A loop suture was placed through the mesh T5, 2 cm from its medial aspect with the help of the needle (Fig.15.4). Both ends of the suture were pulled above the tubercle area by the Reverdin's needle and then inserted into the medial tip of the preshaped Hertra mesh.

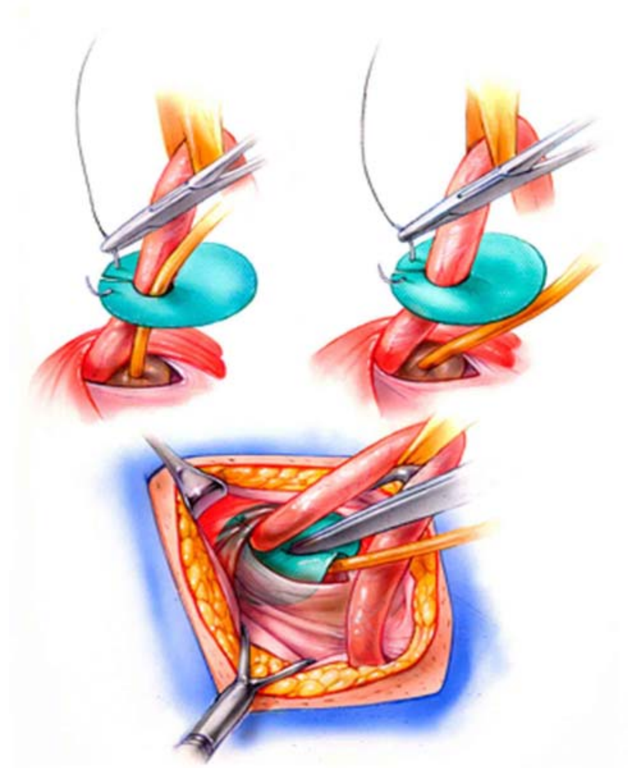

FIGURE 15.3. A Foley catheter facilitates the placement of a plug T4 around the spermatic cord in the preperitoneal space.
The T4 is placed around the cord or cord and Foley. The opening is closed and the T4 is placed over the balloon of the Foley. The deep ring is narrowed over the T4 and the catheter is removed.

A Reverdin's suture needle, difficult to find in the United States but readily available in Europe, is an old valuable instrument for placing sutures in distant areas with good hand control. It is actually a combination of a needle holder and a needle. It comes in different sizes and curvatures and has a handle with a knob that controls the

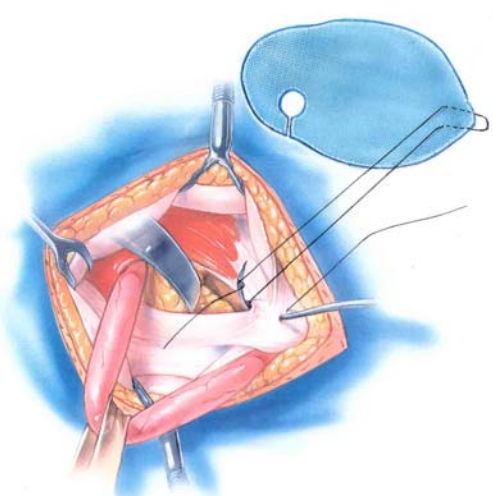

FIGURE 15.4. A Reverdin's needle facilitates the preperitoneal implant of a plug T5 by placing two loop sutures on the plug

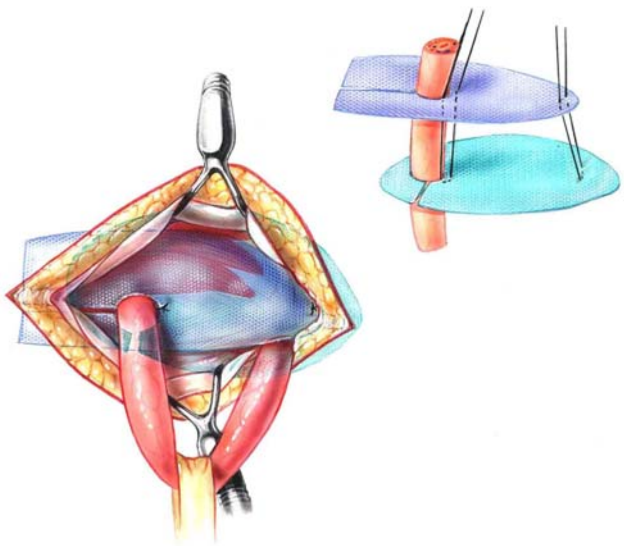

FIGURE 15.5. The posterior wall has been closed over the implanted plug T5. The two loop sutures are inserted in the preshaped mesh and are tied, controlling their tension.

opening and closure of the eye of the needle, similar to the eye of a sewing machine needle. Suture material placed in the needle's eye can easily and safely be pulled or pushed through tissues.

A loop suture was also placed near both openings for the exit of the spermatic cord in the T5 and the Hertra mesh. The posterior wall was closed without tension over the plug *T5,* and both sutures were tied over the preshaped Hertra mesh, controlling the tension between the two anchored prostheses (Fig. 15.5). Since the distance from the opening through which the cord passes to the medial tip is 6 cm in the Hertra and 8 cm in the T5, the medial aspect of the T5 is 2 cm longer and will reach Retzius' space.

After dealing with all kinds of direct or indirect hernia protrusions and the possible implants that could be used, the preshaped Hertra 1 or Herta 2 was selected. The mesh was implanted on the floor of the inguinal canal. The medial tip of the prosthesis was placed to overlap the pubic tubercle by at least 1 cm. The lateral aspect of the prosthesis ended about 3.5 cm lateral to the deep inguinal ring, and this is where the blunt dissection of the closed space ended. This preshaped mesh required adjustments in less than 1 % of the cases (7). If the mesh was too long, trimming its proximal tip altered it. If the mesh was too short, its tip was pulled medially to overlap the pubic tubercle by 1 cm. In this case, the spermatic cord followed a short horizontal course on the floor of the inguinal canal before its exit trough the opening in the Hertra mesh. The external oblique aponeurosis was always closed over the mesh and below the spermatic cord (Fig. 15.6). The loss of obliquity of the inguinal canal, while important in pure suture repairs, plays no role in prosthetic repair. This closure allows the formation of a triple layer between the deep ring and the pubic tubercle, an area that is prone to recurrence. The three layers are the transversalis fascia below, the aponeurosis of the external oblique above, and the preshaped mesh in the middle (Fig. 15.7).

RESULTS

A total of 3,422 hernioplasties were performed from 1989 to 1997, and 275 from 1997 to 1999.

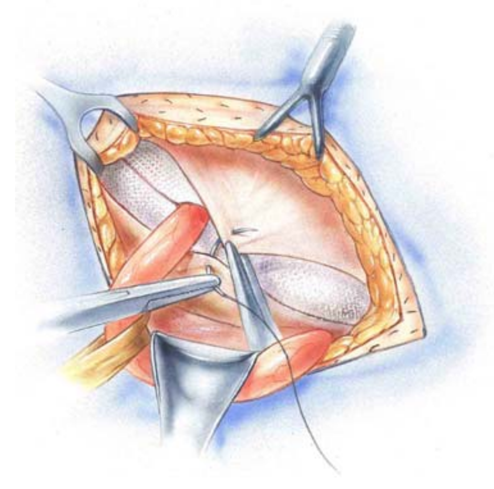

FIGURE 15.6. The external oblique aponeurosis is closed over the mesh, under the spermatic cord.

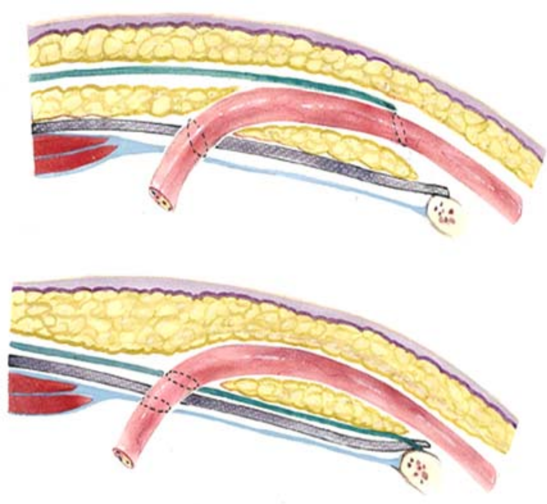

FIGURE 15.7. If the spermatic cord is in a subfascial position, the medial aspect of the floor of the inguinal canal is protected only by a mesh and transversalis fascia. If the spermatic cord is in a subcutaneous position, a triple layer is formed (transversalis fascia, mesh, and external oblique aponeurosis), a stronger protection against recurrences in an area where they occur more frequently.

In the first group, a Hertra mesh was used with or without a three-dimensional plug, which was placed in the deep ring of all indirect inguinal hernias.

In the second group, the T 4 polypropylene prosthesis was used 130 times in medium and large indirect defects. A narrowing of the deep ring was performed 45 times in small indirect inguinal hernias. The T5 prosthesis was used six times in direct hernias with loss of substance of the posterior wall, instead of an unshaped preperitoneal mesh, which implanted in similar cases of the first group. The Herta mesh was implanted alone in all other direct hernias.

The results of the first group have been reported (7). The results of the second group were similar. The results of all 3,697 repairs are summarized as follows:

Ninety-seven percent of the patients were operated on under local anesthesia. The average stay of the patients at the surgical center was 150 minutes. All patients were instructed to walk 2 miles daily after surgery.

A total of 2,995 repairs (80%) were available for long-term follow-up and were actually examined by a surgeon. There were four recurrences, with a follow-up of 1 to 10 years. There were six persistent inguinal neuralgias, which were treated successfully with neurectomies; all were in patients in whom soft mesh was used. Two prostheses were removed due to persistent drainage, which resulted from wrinkled soft meshes.

There were no mortalities, and other complications were minor. Minimal postoperative discomfort was observed, especially in those patients who ambulated immediately.

CONCLUSION

Three-dimensional plugs have been used with or without a mesh in the repair of primary inguinal hernias. This is the first time that a flat mesh has been used as a substitute for a three-dimensional plug in a totally sutureless repair. Sutures were used only six times for direct hernias with loss of substance in the posterior wall of the inguinal canal. The importance of rigidity in a preshaped sutureless mesh has been discussed.

The results demonstrate that this technique is simple and easy to learn. Compared to other tension-free repairs, there are fewer recurrences and complications, as well as less tissue trauma. The preshaped mesh technique saves surgical time. Its also prevents the possible contamination that results from handling a prosthesis that needs to be shaped by hand.

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