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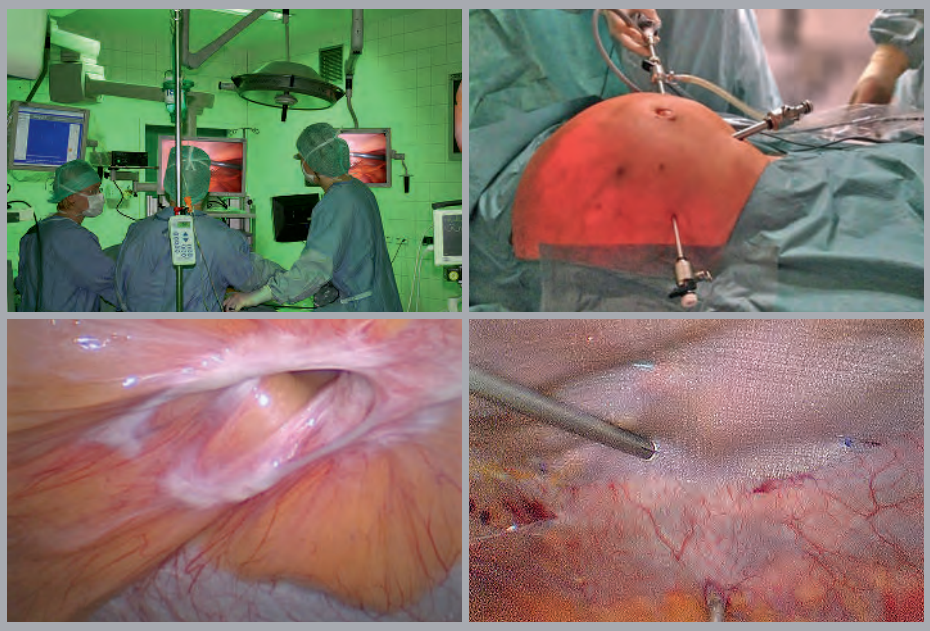
LAPAROSCOPIC REPAIR OF INCISIONAL HERNIAS

3rd Edition



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1.0 Introduction

With an incidence of up to 20%, incisional hernias are the most common late postoperative complication following abdominal surgical procedures[1]. Moreover, a substantial number of these patients (up to 52%) will develop a recurrent hernia due to a variety of causes[2]. Given these high numbers, the treatment of incisional hernias has major socioeconomic importance.

Incisional hernias may have numerous causes (see **Chapter 3**). The causes may be surgical, relating to the technique of abdominal wall closure, or they may involve patient-dependent factors. The latter include age, nutritional status, underlying disease, coexisting diseases, previous operations, and disorders of collagen metabolism[1].

The high recurrence rate of incisional hernias (25–52%) after conventional suture repairs, has prompted a change in incisional hernia surgery, which began with the alloplastic technique of *Stoppa* and *Rives* in the 1970s and received further impetus with the first laparoscopic incisional hernia repair by *LeBlanc* in 1991 [2, 3].

The use of prosthetic materials to stabilize the abdominal wall has led to a marked decrease in recurrence rates[2]. Among the various alloplastic techniques that are available (see **Chapter 4**), the sublay method has yielded excellent results compared with the onlay and inlay techniques[4]. Placing the mesh material beneath the muscular layer of the abdominal wall appears to be a crucial factor in lowering the recurrence rate[32, 45, 55–58, 60, 98].

Conventional alloplastic repair techniques involve considerable dissection of the abdominal wall. This causes significant abdominal wall trauma, which appears to be responsible for the high rates of wound infection and wound complications associated with these techniques.

When an incisional hernia is repaired by the laparoscopic placement of an intraperitoneal mesh, there is no need to separate the abdominal wall layers. This not only reduces trauma to the abdominal wall but also lowers the incidence of wound infection. The repair is completed by intraperitoneal placement of an antiadhesive mesh.

Moreover, the laparoscopic intraperitoneal mesh repair bypasses the original operative site and thus avoids direct contact with old foreign material and any persistent cutaneous germs.

As a result of this development, laparoscopic techniques have been used with increasing frequency in recent years for the repair of abdominal wall hernias.

High-cost implants and suboptimal mesh materials posed a serious initial obstacle to the widespread use of laparoscopic incisional hernia repairs. These problems have prompted numerous innovations for mesh implants.

This booklet includes the latest discoveries on the laparoscopic intraperitoneal onlay mesh repair as an effective addition to the spectrum of abdominal wall hernia repairs, including the development of innovative mesh implants.

2.0 Epidemiology of Incisional Hernias

Incisional hernias are among the most frequent late postoperative complications of abdominal surgery that require operative treatment[1]. The incidence rates in published studies range from 4% to 24%[6,7]. The average incidence appears to be in the range of 5–10%[8]. Because of these figures, incisional hernias have a significant long-term impact on postoperative morbidity. It is estimated that approximately 800,000 laparotomies are performed annually in Germany alone.

Approximately 120,000 new incisional hernias develop each year, and approximately 100,000 incisional hernia repairs are performed, with an estimated annual cost volume of approximately 500 million EUR. This does not include the costs incurred by lost job time or occupational disability leading to early retirement. The socioeconomic costs of incisional hernias are substantial, therefore.

3.0 Etiology and Pathogenesis of Incisional Hernias

The development of an incisional hernia is a multifactorial process. Basically, it occurs when a disproportion arises between the intra-abdominal pressure load and the strength of the complex myofascial framework or surgically induced scar[9]. So far, no single factor has been identified, that is sufficient in itself to cause an incisional hernia. Only 25% of incisional hernias develop during the first year. The causes of incisional hernias fall into two broad categories[10]: technical aspects of the laparotomy closure and biological factors that affect scar healing (Table 1).

Table 1: Factors in the etiology and pathogenesis of incisional hernias[1, 10]

Technical factors	Biological factors
Suture technique	Age, gender
Suture material	Wound healing problems
Incision technique	Associated diseases Obesity, anemia, diabetes mellitus, cancer, renal disease, malnutrition
	Exogenous agents Nicotine use, medications
	Collagen disorders
	Preoperative medication Steroids
	Postoperative course Infections

Absorbable suture materials lose their stability in 4–8 weeks. The formation of stable scar tissue is particularly important, therefore. The degree of stability produced by the scar is a controversial issue[11]. In experiments on animals, from 15% to 50% of the initial abdominal wall strength was achieved in 3 weeks[12]. It probably takes 1–2 years until definitive scar-tissue repair is complete[10, 12, 13]. Nevertheless, the scar is competent to withstand most ordinary stresses following a technically proficient suture closure.

High suture tension and the development of necrosis may lead to wound infection[6]. These factors may possibly account for the early postoperative occurrence of an incisional hernia, but they cannot explain its development at a later date.

Midline laparotomies are associated with the highest risk of incisional hernia[7], but in the light of final analysis, the yielded data is heterogenous[90]. The fascia is supposed to be subjected to particularly strong tensile stresses and pressure loads in the region of the upper median plane, which consequently is the most frequent site of occurrence. Alternative approaches, especially via transverse laparotomies, should be considered whenever possible. In many cases, however, surgeons are reluctant to sacrifice the advantages of a rapid, extendable midline incision that will permit exploration of the entire abdomen if needed. Emergency procedures are associated with a higher risk of incisional hernia formation[7].

In studies of collagen metabolism, some patients who developed an incisional hernia several years after laparotomy were found to have a defect in specific collagen synthesis[14,15]. The analysis of extracellular matrix components in patients with incisional hernias has consistently shown an increased proportion of immature type III collagen in the skin, fascia, or peritoneum, with a corresponding decrease in the ratio of collagen types I and III[13-17]. The suspicion of a genetically linked, systemic connective tissue disorder is supported by finding a decreased expression of MMP-1 and an increased expression of MMP-13 in the skin of these patients.

A primary defect of scar formation would account for the high recurrence rates after repetition of the initially failed procedure and would explain the increased incidence of hernias in patients with collagen disorders. It also supports the rationale for changing to alloplastic materials in the treatment of incisional hernias[9].

The importance of technical factors is reflected in the varying incidence of incisional hernias among different surgeons, although the differences were not found to be statistically significant[18].

It is likely that a tight transmuscular suture promotes necrosis of the wound margins and leads to a higher incidence of incisional hernias[19]. Moreover, all-layer sutures are associated with fewer incisional hernias than closure in multiple separate layers, at least in the midline region[20].

This may be because the wound margins cannot always be broadly encompassed in a layered closure[21,22]. A continuous suture is preferred over simple interrupted sutures, as it distributes the stresses more evenly along the suture line[20]. A 4:1 ratio of suture length to wound length is recommended for continuous sutures, and the stitch interval should not exceed 1 cm[7]. This results in a significantly lower rate of incisional hernias[7].

The superiority of nonabsorbable sutures over absorbable sutures for wound closure has not been definitely established. In patients with delayed wound healing, a history with risk factors, and a mechanically stable absorbable suture line, there is only a 4- to 8-week period in which there is an increased incidence of wound disruption and incisional hernia formation.

In summary, the pathogenesis of incisional hernias is a multifactorial process. It is very likely that the coexistence of several adverse factors, including constitutional features, contribute to the development of an incisional hernia.

4.0 Conventional Repair Techniques

4.1 Conventional Repair Techniques without Alloplastic Materials

The indication for an incisional hernia repair is based on the subjective complaints of the patient and on impending complications. The most serious complication is the incarceration of bowel tissue in the hernial opening, causing a critical reduction of blood flow to the entrapped viscera. Impending skin ulceration is another consequence of large abdominal hernias. Intestinal organs may protrude from the abdominal cavity into the hernia sac, depending on the size of the fascial defect, causing adverse mechanical effects as well as cosmetic deformity. The defect in the abdominal wall inhibits diaphragmatic breathing and causes significant limitation of strength and motion. Incarceration is an absolute indication for hernia repair. All other cases require a preoperative risk assessment. Returning the herniated tissues to the abdominal cavity changes the position of the diaphragm, resulting in improved lung performance. A risk analysis for pulmonary compensation capacity should be included in preoperative preparations for an incisional hernia repair.

Particularly strict criteria should be applied in selecting patients with hepatic cirrhosis and ascites for a hernia repair. The mortality and morbidity rates are substantially higher in these patients, and the indications for operative treatment should be viewed very critically in this subgroup[23].

The oldest techniques, and those having the poorest long-term results, are conventional suture techniques for closing the abdominal wall and repairing an incisional hernia. The suture techniques have been repeatedly modified over the years. Ultimately, only the initial part of the operation has been standardized. The first step in the operation is scar excision, followed by the lysis of adhesions.

Thus, this type of incisional hernia repair always includes a relaparotomy. After the lysis of adhesions, the scarred fascial margin is excised and the abdomen is closed with an initial row of peritoneal sutures. This is followed by the actual fascial repair. This step may involve duplication of the fascia as in the Mayo technique, or it may involve an edge-to-edge reapproximation of the fascial margins. Suture options include interrupted sutures, mattress sutures, double mattress sutures, simple interrupted sutures, and continuous sutures. A variation is the “swinging-door repair,” which may be single (including only the upper fascial layer of the rectus sheath) or double (encompassing both layers)[24]. In this technique the fascial layer is incised approximately 3–5 cm from the midline and folded over to the midline as a flap to reinforce the median closure (Fig. 1).

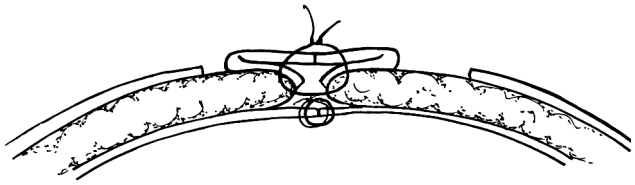

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Fig. 1
The swinging-door repair of *Farthmann* and *Mappes*[24].

Retrospective studies on incisional hernia repairs with simple suture techniques are reviewed in **Table 2**. An advantage of these studies is their long follow-up periods ranging from 2 to 7 years. Long follow-ups are necessary for an accurate evaluation of the methods. Late recurrences after 10 years or more are known to occur with inguinal hernia repairs. Presumably the pathophysiology of this process is based on an abnormal ratio in the synthesis of collagen types I and III.

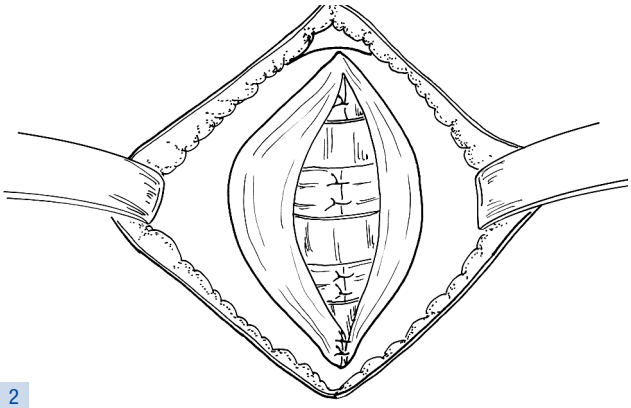
Although the long-term results of simple suture repairs are not convincing, a few indications for these techniques can be derived from the study data. These techniques may be appropriate if the hernial opening measures less than 3 cm and the patient is undergoing an initial repair. Whenever possible, a horizontal repair should be done using nonabsorbable, monofilament material and a continuous suture line with a 4:1 ratio of suture length to wound length[25-33].

One alternative to simple suture techniques is the autodermal hernioplasty, in which the old scar is used for fascial reinforcement. The necessary skin is mobilized from the old scar as a flap or strip, and the subcutaneous tissue is removed. The mobilized flap or strip is pretreated for 5 seconds with boiling NaCl solution. This contact is brief enough to protect the corium from thermal injury. All cutaneous flora are eradicated by incubating the flap or strip in 96% alcohol for 3 minutes, then washing the flap before use[34].

The *Lezius* repair employs tissue strips that incorporate portions of the rectus muscle (Fig. 2)[35]. The strips are sutured in the midline at the level of the posterior layer of the rectus sheath. The anterior fascial layer is dissected off the rectus muscle, and the muscle is incised laterally so that the strips can be laced through.

Table 2: Long-term results of simple conventional suture repairs

Author	Year	Number (n)	Follow-up		Recurrence Rate
			Years	Rate (%)	
Langer, Sweden	1985[25]	72	7.0	74	31
Van der Linden, Netherlands	1988[26]	47	3.3	100	55
Read, USA	1989[27]	169	5.0	89	25
Männinen, Finland	1991[28]	57	4.5	92	34
Hesselink, Netherlands	1993[29]	231	2.9	98	36
Luijendijk, Netherlands	1997[30]	68	variable		54
Paul, Germany	1997[31]	111	5.7	84	53
Luijendijk, Netherlands	2000[94]	97	2.2	84	46



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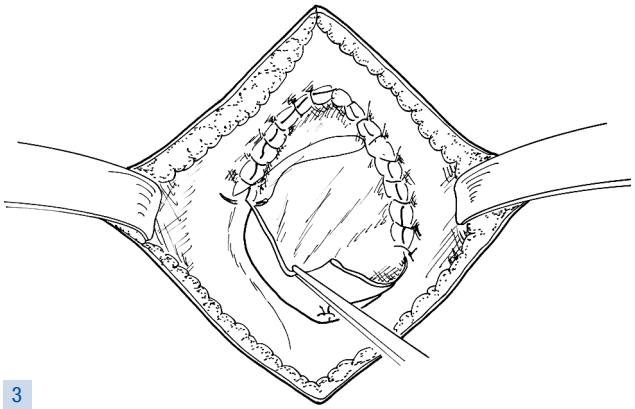
The *Lezius* repair.



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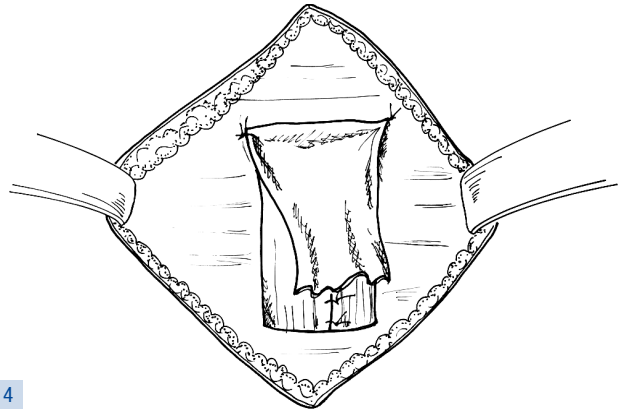
Rehn skin-flap repair using inlay technique.



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Rehn skin-flap repair using onlay technique.

The strips should overlap at the center and are also sutured together at that point. In the *Rehn* skin-flap repair, the skin can be utilized as a biological inlay or onlay mesh (Fig. 3 and Fig. 4)[36].

This technique is not widely practiced, and there are only a few centers that have adequate experience with this type of repair. This makes the published data all the more remarkable. With acceptable follow-up periods ranging from 2 to 5 years and follow-up rates of 84% to 100%, good results have been achieved in terms of reported recurrence rates, which range from 1% to 7.6%[37,38]. The recurrence rates vary between 1% and 14% (Table 3), indicating better results than those obtained with simple suture repairs[39–42]. The flap and strip techniques have three major drawbacks, however. First, surgeons have had very little experience with these repairs, which often have only historical validity. Second, tissue of poor quality is used in the repair. The hernia was caused in part by abnormal scar formation yielding a relatively fragile mix of collagen types I and III, but this same scar tissue is used in the repair. Third, these repair techniques correlate with an unacceptably high rate of wound healing problems ranging from 6% to 29%.

These techniques are most appropriate for larger hernias that cannot be reapproximated with sutures or cannot be repaired with alloplastic material because of infection.

For completeness, we should mention the abdominal-wall-component separation technique of *Ramirez*[43]. This technique may be suitable for the plastic repair of very large hernias (e.g., following a laparostomy with marked lateral deviation of the muscle bellies).

Table 3: Results of autodermal hernioplasty

Author	Year	Number	Follow-up years	Wound Problems (%)	Recurrence Rate (%)
Kozuschek[40]	1983	105	3	29	3.2
Kranich[41]	1990	66	4	6	3.2
Watier[42]	1992	30	2	?	3.3
Chareton[39]	1994	25	5	8	12.0

4.2 Conventional Repair Techniques with Alloplastic Materials

The simple suture techniques are marred by poor long-term results, and the recurrence rates may exceed 50%. This led in the early 1980s to the introduction of alloplastic mesh techniques for incisional hernia repairs[37].

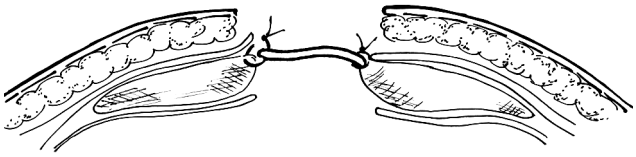
To date, no randomized prospective cohort studies have been conducted on *"suture repair versus mesh repair of incisional hernias".* The retrospective studies published so far have consistently shown better results with alloplastic repairs (Table 4). This led the **American Hernia Society** to establish the **mesh repair as the standard operative treatment for incisional hernias.**

The conventional alloplastic options are the *inlay, onlay, sublay,* and *open IPOM repairs*.

In the *inlay technique*, the mesh is sutured into the defect to obtain a tension-free reconstruction of the abdominal wall (Fig. 5). Generally, it is necessary to perform a relaparotomy with lysis of adhesions. A great variety of mesh materials have been used, and no clear preference has emerged for any one type of mesh. Recurrence rates of up to 44% have been described, regardless of the material used[44,46–48]. Thus, the inlay technique has the poorest results of any of the mesh repairs (Table 5). Using this technique, the mesh is circumferentially attached to the fascial margins with continuous sutures. This is a site of predilection for recurrence as the mesh tears free at its line of attachment to the fascia. The mesh does not overlap the fascial margins in the inlay technique.

Table 4: Comparison of suture and mesh techniques in incisional hernia repairs

Author	Year	Technique	n	Recurrence Rate (in %)	Follow-up (months)
Liakakos[96]	1994	Suture repair Polypropylene	53/49	25/8	90/90
Schumpelick[45]	1996	Suture repair Polypropylene	190/82	33/7	64/64
Koller[124]	1997	Suture repair PTFE mesh	70/26	68/13	24/24
Luijendijk[94]	2000	Suture repair Polypropylene	97/87	46/23	26/26
Burger[101]	2004	Suture repair Polypropylene	97/87	63/32	97/98



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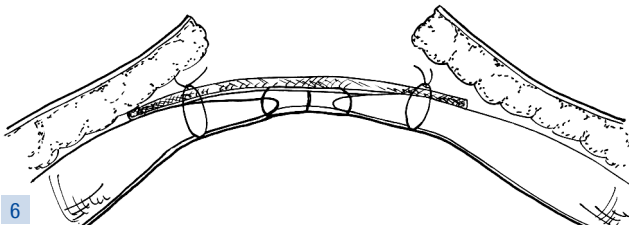
Alloplastic repair using mesh inlay technique.

Table 5: Results of hernia repairs with inlay mesh

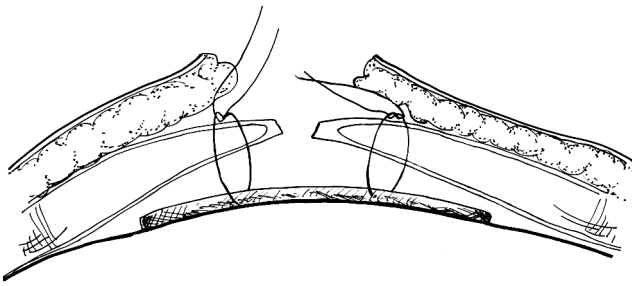
Author / Year	n	Material	Follow-up	Recurrence Rate
Ambrosiani, 1994[48]	83	ePTFE	>12 month	42%
Anthony, 2000[125]	29	PP	44 month	29%
de Vries, Reilingh, 2004[46]	23	PP	33 month	44%

PP (polypropylene); ePTFE (expanded polytetrafluoroethylene).

The *onlay technique* was introduced by *Chevrel*[49]. Like the inlay technique, this procedure requires a relaparotomy and lysis of adhesions. The mesh is placed in the subcutaneous plane to reinforce the suture repair (Fig. 6). The subcutaneous tissue is widely dissected laterally from the anterior fascial layer of the rectus sheath. One disadvantage of this technique is that it reduces blood flow to the bradytrophic subcutaneous tissue, which is supplied by perforator vessels from muscular branches of the abdominal muscles.



6 Diagrammatic representation of the onlay technique for hernia repair.



7 Diagrammatic representation of the sublay technique for hernia repair.

Table 6: Results of hernia repairs with onlay mesh

Author	n	Material	Follow-up		Mortality	Results (%)	
			Years	Rate		Wound infection	Recurrence
Molloy[50]	50	Marlex	4	100	0	26	8.0
Kennedy[51]	40	Gore-Tex	4	84	2.5	5	2.5
Liakakos[96]	49	Marlex	8	98	0	4	8.0
Küng[52]	47	Marlex	6	83	0	?	13.3
Vestweber[53]	36	Prolene	3	86	2.7	27.7	5.5
Leber[126]	118	Marlex	6.7	88	0	7	14.8

All types of mesh have been used in onlay repairs. Meshes made of ePTFE have shown problems with subcutaneous seroma formation, which is less pronounced with other mesh materials. Overlapping the scar at least 3 cm on all sides provides a stability that results in a strong repair. Another drawback of this method is the large raw surfaces that are created (see above), and wound infection rates as high as 27.7% have been reported[50]. The subcutaneous placement of the mesh may cause a painful or uncomfortable corset sensation in some patients, but this complication may be largely preventable by using different types of mesh (see **Chap. 5**)[44,50–55].

The recurrence rate after onlay repair is significantly lower than with the inlay technique (Table 6).

The third method – the *sublay technique* of mesh implantation – is the most widely practiced alloplastic repair (Fig. 7). Introduced by *Rives* and *Stoppa*[57, 61], the sublay technique involves dissection of the retromuscular space in front of the posterior fascial layer on both sides of the hernia, which then allows the mesh to be inserted and fixed to this layer with sutures. In cases where the peritoneum and posterior fascial layer can be completely preserved, it is safe to use a polypropylene or polyester mesh.

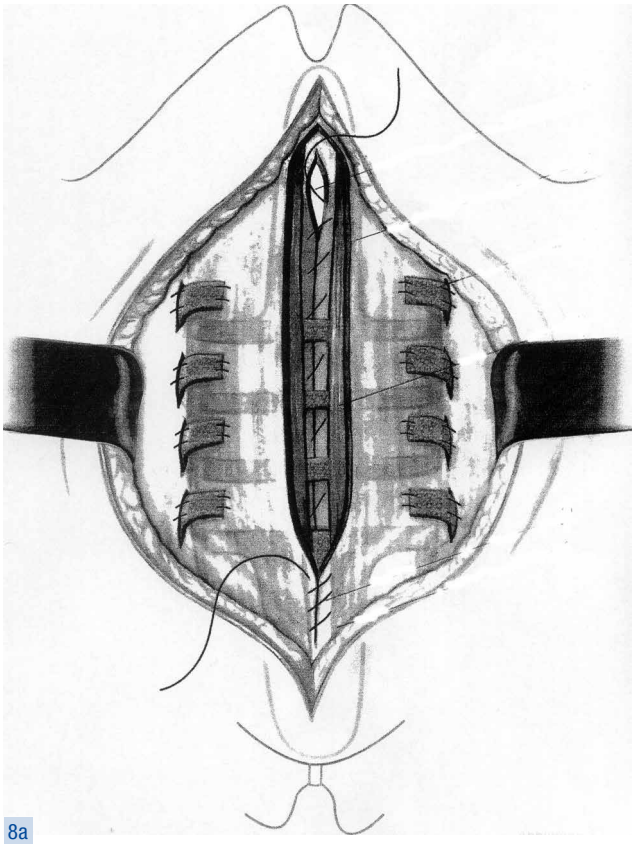
Contact with the bowel should be avoided when these meshes are used to help prevent the occurence of long-term fistula formation to bowel or bladder. The sublay technique is completely tension-free because after closure in the midline, the supportive layers of the abdominal wall act as a sturdy abutment. In terms of recurrence rates, it has yielded the best results of any of the incisional hernia mesh repairs, with an average recurrence rate between 5% and 10%[45,56,58-60] (Table 7). On the other hand, this technique has been associated with wound infection rates as high as 29%. When polypropylene or other meshes besides ePTFE are used, it is not strictly necessary to remove the mesh[4,32,45,55–60,62–64]. This is not true with ePTFE meshes, which should always be removed in cases of infection.

The recurrences were described as occurring at the upper and lower edges of the mesh. The entire scar had not been covered with mesh during the initial repair. Laparoscopic inspection permits a complete and accurate assessment of the scar. At this time, it is not uncommon to find a "Swiss cheese" pattern of small hernias permeating the upper or lower segment of the scar. The concept of the "fatty triangle" has been adopted in the literature as a means of preventing a recurrence at the upper and lower ends of the scar[65] (Figs. 8a, b).

In 1999, *Kubo* developed a special sublay repair technique called rectus banding[91,92]. In this technique the rectus abdominis muscle is partially encircled with 2-cm-wide Prolene strips placed at 2-cm intervals in the sublay position (Figs. 8a, b). The historical origin of this technique is the skin-graft repair of *Lezius*. The goal is to achieve a simple and cost-effective repair with secure mesh fixation. Employing this technique, the mesh strips eliminate the painful abdominal-wall stiffening that may occur with heavyweight or mid-weight meshes. Hernia recurrence between the mesh strips, according to the authors, has not proven to be a significant problem on long-term follow-up.

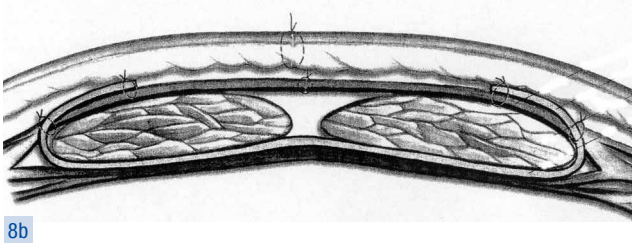
Table 7: Results of hernia repairs with sublay mesh

Author	n	Material	Follow-up (months)	(%) Recurrence
Adloff[56]	130	Mersilene	36	5
McLahan[57]	106	PP	24	3.5
Amid[58]	75	Marlex	?	1
Schumpelick[45]	82	Marlex	>60	7
Sugerman[98]	98	Marlex	>18	4
Ladurner[55]	52	PP	6–33	2
Petersen[60]	50	Goretex/PP	18	10
Bencini[32]	49	PP	18	6.0



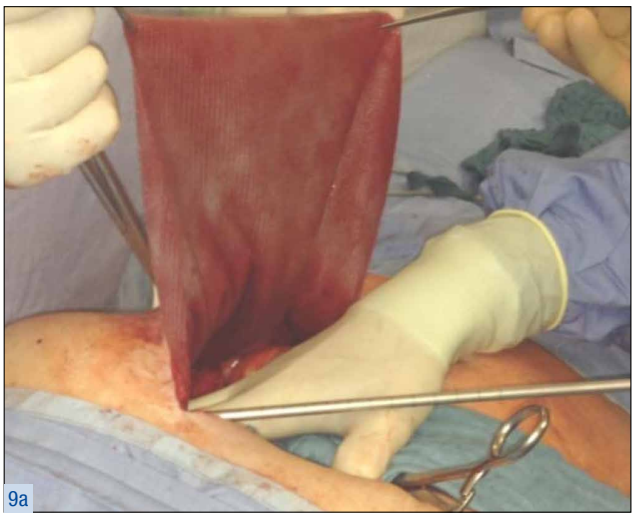
8a

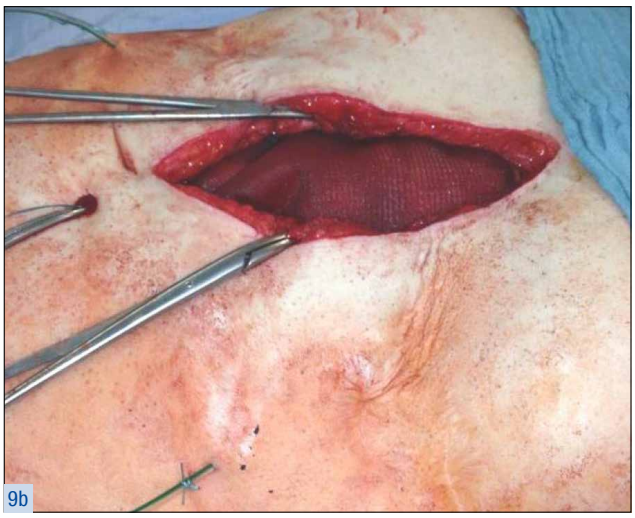
Diagrammatic representation of the operative site.



8b

Abdominal cross section showing the position of the Prolene mesh strip.


9a


9b

Open intraperitoneal onlay mesh (open IPOM) technique.

The *open intraperitoneal onlay mesh technique* (open IPOM) (Figs. 9a, b) is an open surgery variant of the sublay method. If the posterior layer of the rectus sheath or the peritoneum is found to be deficient, it will be necessary to place the mesh on the bowel beneath the posterior rectus sheath and peritoneum. "Onlay" in this case means that the mesh is placed directly on the bowel and not on the rectus sheath. The drawback of this method is that it limits the selection of mesh materials that can be safely placed in contact with the bowel. At present, only special meshes with anti-adhesive barrier can be safely used without a long-term risk of enteric fistula formation[66]. The results appear to be comparable to those of sublay repairs.

In summary, the alloplastic repair of incisional hernias has led to a significant decline in recurrence rates. The main disadvantages of mesh repairs are the high incidence of wound infection and the difficulty of placing the sublay mesh in the "fatty triangle" (epigastrium and suprapubic region).

5.0 Alloplastic Materials in Incisional Hernia Surgery

The use of alloplastic mesh materials in abdominal hernia repairs has significantly reduced the incidence of recurrent hernias[93,94,95]. Several studies have shown that the risk of a recurrent hernia following an alloplastic mesh repair is markedly lower than after a non-mesh repair[34,96,94,45,64,61,95].

The development of new, complex tissue materials is continuing.

The goal is to develop an optimum mesh structure and weight, whose ideal properties are shown in Table 8.

Table 8: Ideal properties of an alloplastic mesh[97, 69]

Chemically inert	Some flexibility
Sterilizable	Mild foreign-body reaction
Stable on tissue contact	Nonallergenic
Good mechanical strength and stability	Noncarcinogenic

The table below lists the specific requirements that a mesh implant must satisfy for an IPOM repair:

Requirements of an ideal alloplastic mesh implant[69,97,98]

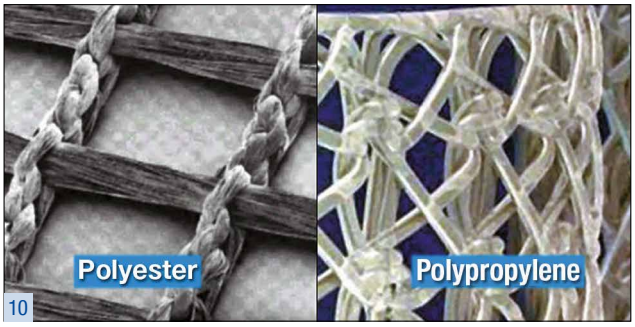
- Biocompatability
- Ready-made material that can be tailored to the individual defect
- Good handling, good compatibility with current fixation techniques
- No adhesion formation between the mesh and bowel
- Rapid mesh ingrowth at the side facing the periteoneum
- Dynamometric properties that can adapt to the physiology of the abdominal wall
- Long-term stability of mechanical properties (minimal stiffening, shrinkage, and degradation of the mesh)

Further progress is needed in solving known problems related to mesh properties:

- Induction of chronic inflammation
- Mesh behavior in response to infection
- Susceptibility to shrinkage / increased scar formation
- Postoperative complaints (foreign-body sensation)
- Adhesions and fistula formation.

Mesh studies in recent years have shown that reducing the amount of material in the mesh results in greater elasticity of the induced scar plate. In the case of polypropylene (PP), a direct correlation exists between the amount of material implanted and the foreign-body reaction that is induced. This discovery has largely eliminated the problem of a "stiff abdomen" that initially occurred in mesh repairs of incisional hernias.

Large-pore meshes have scientifically proven advantages. They avoid the dreaded "bridging effect" (in PP structures with a pore size < 1 mm), which would prevent peritonealization of the mesh (Fig. 10).



10

Examples of different pore sizes in synthetic meshes.

Large pores are also essential in combating mesh infections. The host tissues can mount an effective response only if the pores are permeable for host granulocytes (10–15 µm).

This problem is also reflected in the structure of the mesh, where monofilaments or dual filaments create a large- or small-pore mesh architecture compared with multifilaments or expanded polytetrafluoroethylene (ePTFE) with micropores.

Most mesh implants today are made from synthetic materials. In principle, synthetic mesh materials can be divided into absorbable and nonabsorbable products. While large-pore polypropylene or polyester meshes are used in inlay, onlay, and sublay repairs, composite meshes – instead of pure polytetrafluoroethylene (ePTFE) meshes – are increasingly being developed for IPOM repairs.

Composite meshes are designed to allow direct contact between the mesh and bowel in the IPOM technique. A major drawback of these meshes in the past has been high material costs, which – prior to introduction of the "special expenses rule" in Germany – limited the widespread use of laparoscopic techniques.

At present, three product strategies are being pursued in the development of synthetic mesh implants:

1. Composite meshes with nonabsorbable functional surfaces
2. Composite meshes with an absorbable functional surface on one side
3. Layered meshes

1. Composite meshes with nonabsorbable functional surfaces

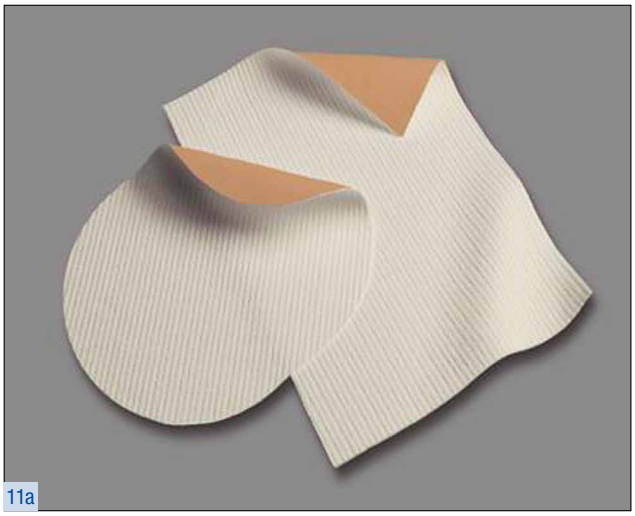
Meshes (examples)

- DualMesh® (Gore®): ePTFE with a small-pore visceral surface and a coarse-textured fascial surface
- TiMESH® (GfE): titanium-coated PP

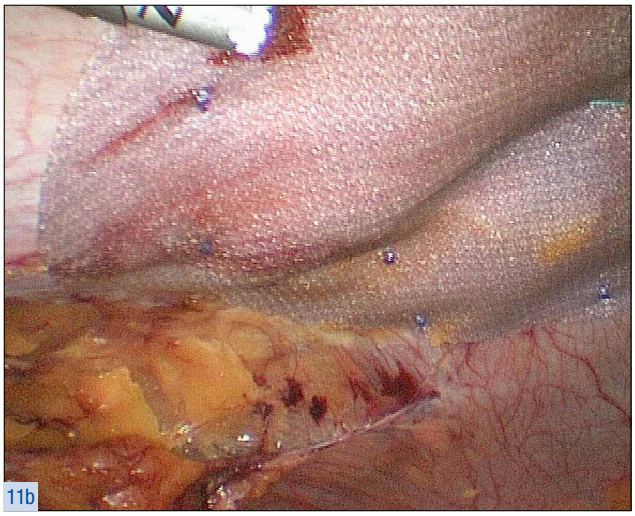
Most experience to date with intraperitoneal mesh placement has been reported for the material ePTFE (Figs. 11a, b). Even studies in large series of patients have shown minimal adhesion formation and absence of fistula formation with this material[87, 99]. Among the known disadvantages are circumscribed integration of the membrane structure into the abdominal wall and a tendency for the implant to undergo shrinkage.

This material can be combined with PP on the fascial side to optimize integration of the mesh and to reduce its susceptibility to shrinkage[100, 101].

Coating the polypropylene mesh with titanium to lower surface tension has reduced implant shrinkage in experimental animals and resulted in less adhesion formation compared with ePTFE[100].



11a Gore-Tex DualMesh® is composed of ePTFE and has two functional surfaces.



11b Ventralight™ ST Mesh with Sepra® adhesion barrier (C.R. Bard Inc.) following intraabdominal placement.

2. Composite meshes with an absorbable functional surface on one side

Meshes (examples)

- Parietex™ Composite (Covidien): polypropylene with a hydrogel coating on one side (polyethylene glycol + glycerol)
- Sepramesh™ (C.R. Bard Inc.) Ventralight™ ST Mesh – Polypropylene with hydrogel coating on one side (disaccharide N-acetylglucosamine glucuronic acid + carboxymethylcellulose)
- Proceed™ (Ethicon) – Polypropylene with polydioxanone (PDS) coating and a layer of oxidized regenerated cellulose (ORC) fabric.
- C-QUR Edge™ (Atrium): polypropylene with an omega 3 oil coating

In this principle the polypropylene base material is coated on one side with a closed, absorbable film that is designed to prevent bowel adhesions during the initial phase of mesh integration. As this protective layer is absorbed, the polypropylene undergoes a simultaneous peritonealization[102].

Numerous animal studies have been done to test the desired properties of mesh implants. The presence of a coating was found to reduce the formation of bowel adhesions compared with uncoated polypropylene[103–109]. In a rat model, it could be demonstrated that polypropylene meshes with a hydrogel coating showed markedly improved antiadhesive properties. Film-coated PP meshes were also found to undergo less shrinkage than uncoated counterparts.

The initial impermeability of the coating is cited as a disadvantage with regard to seroma formation[102].

3. Layered mesh

Mesh (example)

- DynaMesh® (FEG Textiltechnik GmbH, Germany) – a dual-layer composite made of polyvinylidene fluoride (PVDF)-coated polypropylene (PP)

The two-layered structure of the mesh implant consists of PVDF monofilament on the side facing the bowel and polypropylene on the fascial side. The implant has a purely textile, open-pore structure.

Animal studies have shown mild inflammation and less shrinkage compared with conventional mesh implants[110, 111].

Besides these strategies for mesh implant designs, there are other developments that still have minor clinical significance at the present time.

For example, **meshes impregnated with antimicrobial agents** (ePTFE with chlorhexidine and silver carbonate; PVDF + PAAc with gentamicin) have been developed to suppress bacterial colonization after mesh implantation[112, 113], however clinical data obtained through comparative studies demonstrating a clinical benefit from the use of this type of mesh implants are still lacking.

Biological materials and meshes have also been produced in the form of **natural acellular collagen membranes** with the goal of stimulating self-repair processes in the surrounding tissue.

Sample products:

- Surgisis® Biodesign (Cook Biotech): collagen membrane derived from the submucosa of porcine intestine
- Tutomesh (Tutoplast): collagen membrane derived from bovine pericardium
- CollaMend (C.R. Bard Inc.): collagen membrane derived from porcine collagen
- AlloDerm (LifeCell Corporation, U.S.): collagen membrane derived from homologous human skin
- Permacol (Tissue Science Laboratories): collagen membrane derived from porcine skin collagen

A recent publication found a 20% recurrence rate for hernias repaired with decellularized collagen membrane[114]. Another study showed benefits of using this material in infected or potentially infected fields[115].

Adhesion barrier films (e.g., SurgiWrap™ from MAST Biosurgery Inc., USA) have also been developed to reduce adhesion formation. However, animal studies have not shown these films to be advantageous when combined with a coated mesh implant[116].

6.0 Laparoscopic Repair of Incisional Hernias

The method of laparoscopic incisional hernia repair was developed in the early 1990s. The first report, published in 1993, described a ventral abdominal hernia that was repaired entirely by the laparoscopic implantation of an intraperitoneal mesh[81]. The laparoscopic intraperitoneal onlay mesh (IPOM) technique and mesh materials were developed further in subsequent years, and there have been numerous reports on the successful use of the IPOM technique even for large hernial openings, in obese (BMI > 30) and morbidly obese patients (BMI > 40), and in elderly patients[17, 18, 117, 118]. The reduced surgical trauma and lower rates of infection and recurrence are key advantages of the minimally invasive repair[82] (Table 9).

Table 9: Results of laparoscopic incisional hernia repairs

Author	Number of Patients	Recurrence Rate (%)	Infection (%)	Enterotomy (%)
Heniford[87]	850	4.7	0.7	1.5
Heniford[88]	407	3.4	1.0	1.2
Franklin[20]	384	2.9	0.3	1.3
LeBlanc[65]	200	6.5	2.0	0
Berger[9]	150	2.7	1.3	2
Ramshaw[82]	79	2.5	2.5	2.5

In a laparoscopic intraperitoneal mesh repair, it is unnecessary to separate the layers of the abdominal wall. This results in less abdominal wall trauma without disruption of abdominal wall nerve supply, and a lower incidence of wound infection[119,120]. It is essential to perform a careful and complete laparoscopic adhesiolysis prior to mesh implantation. A possible bowel lesion is an important decision-making criterion for further operative management[20].

Another advantage of the IPOM technique is that it bypasses the original field and thus avoids contact with old foreign material and any persistent micro-organisms that may be present[80,82].

For some years, the ePTFE sheet was the only acceptable mesh implant for intra-abdominal use. So far, ePTFE seemed to be associated with very little adhesion formation[71, 85, 4]. Most experience to date has been reported for this material. In 2003, *Heniford et al.* published the results of 850 laparoscopic ventral hernia repairs, 97% of which had been performed with ePTFE DualMesh[3, 83].

The range of meshes available for IPOM repairs has expanded considerably in recent years and now includes composite meshes with nonabsorbable functional surfaces, composite meshes with an absorbable functional surface on one side, and layered meshes composed of many new innovative materials and combinations of materials. Meshes made of biological material are currently also available (**Chapter 5.0**). Besides the special requirements of meshes used in the IPOM technique, the cost of the implant is also an important factor in selecting a mesh for clinical use.

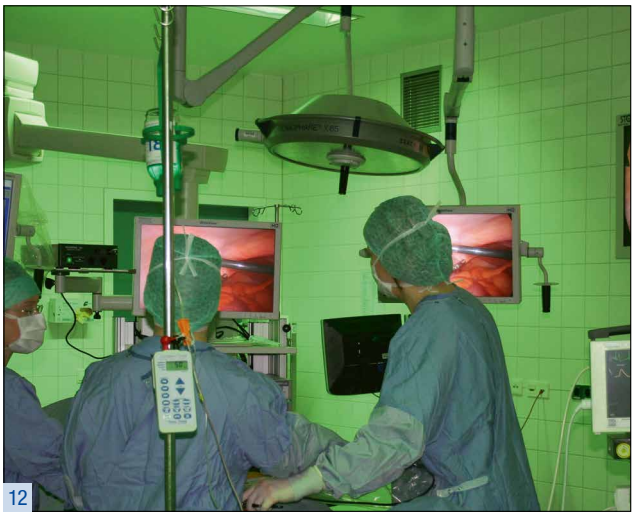
The surgical techniques that are used in laparoscopic incisional hernia repairs are comparable to one another and mostly differ only in the method of attaching the mesh to the anterior abdominal wall. The mesh may be attached to the anterior abdominal wall with transfascial sutures, spiral tacks, or a combination of both. In a review of the literature, *LeBlanc* (2007) found that a successful repair required a large overlap of the implant (5 cm) over the edges of the hernial opening. This appeared to be a more important factor than whether or not transfascial sutures were used[19,121]. Results of prospective randomized studies are not available.

The details of our preferred operative technique are described below.

6.1 Technique of Laparoscopic Incisional Hernia Repair

The surgery is performed under general anesthesia.

The patient is positioned supine. Videoendoscopic surgery should be performed in an operating room in which the surgeon and assistant can quickly alter the direction of the surgery, and thus the viewing angle, without awkward repositioning of the monitors. Multiple monitors should be installed (Fig. 12).

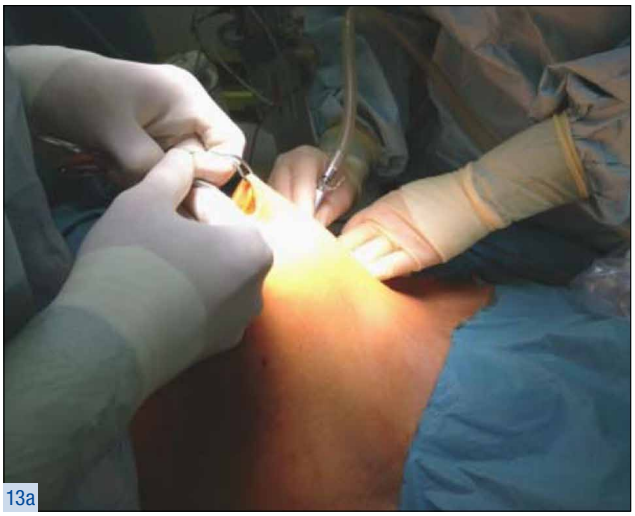


12 Operating room with integrated modular system components, which can be controlled and monitored by a touch-screen interface from within the sterile field.

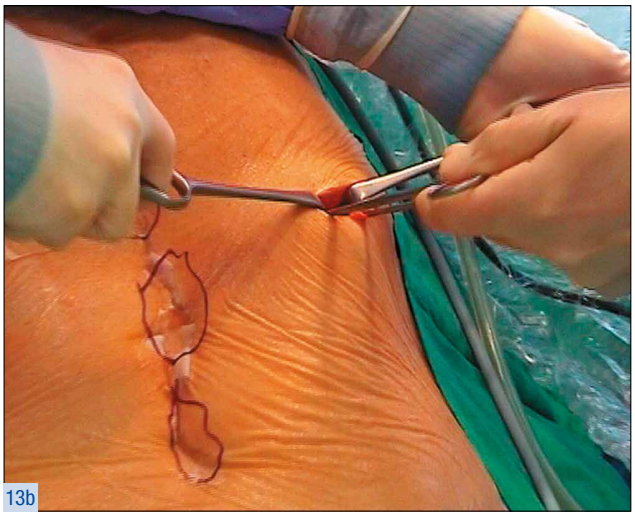
Integrated modular operating systems meet this requirement and enable the surgical team to quickly adjust surgical parameters from within the sterile field. This is particularly important in this type of operation, where unforeseen adhesions may require rapid adjustments in operating direction, patient position, intra-abdominal pressure, light intensity, etc. Current developments in HD camera heads and high-resolution large-format HD video monitors (16:9 aspect ratio) offer the surgeon a new level of video image detail that permits extremely precise surgical dissection.

The primary trocar is introduced through a minilaparotomy at some distance from the site of the incisional hernia. We consistently place this initial trocar below the costal margin in the left upper quadrant of the abdomen, because we know from experience that it causes the least adhesions (Fig. 13a).

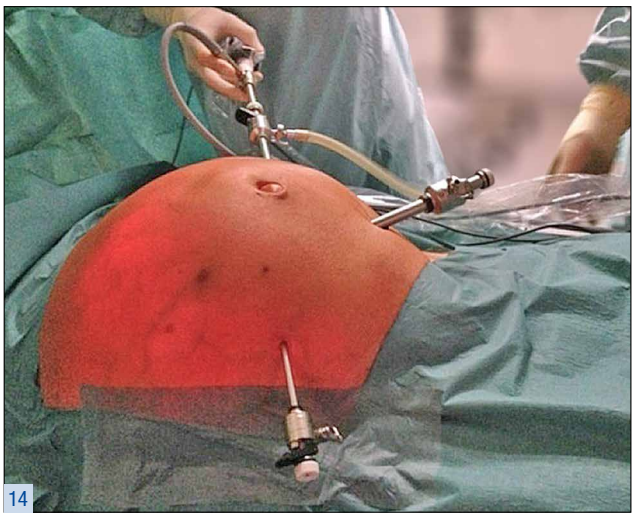
If the hernia is located in this region or if the patient is known to have had previous surgery in the left upper quadrant, the primary trocar can be placed in the right side of the abdomen at least 10 cm from the original surgical scar. It is now decided whether CO_2 will be insufflated through a Veress needle, which is introduced blindly, or through a minilaparotomy followed by the placement of the first 11-mm trocar (Fig. 13b).



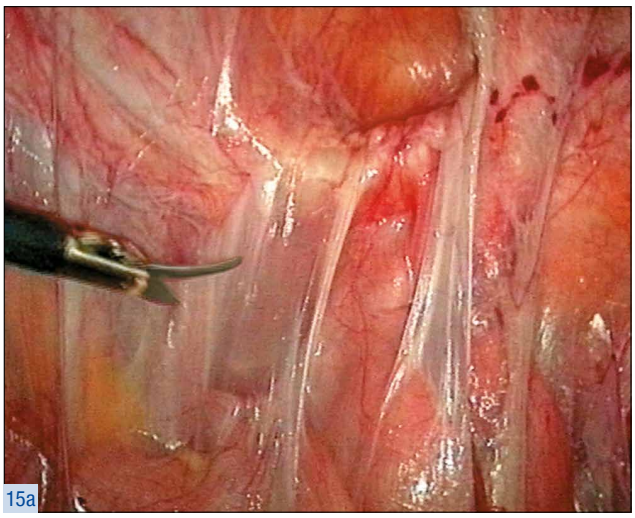
13a Normally, an open surgery approach is not required. Access to the abdominal cavity is obtained by use of a Veress needle.



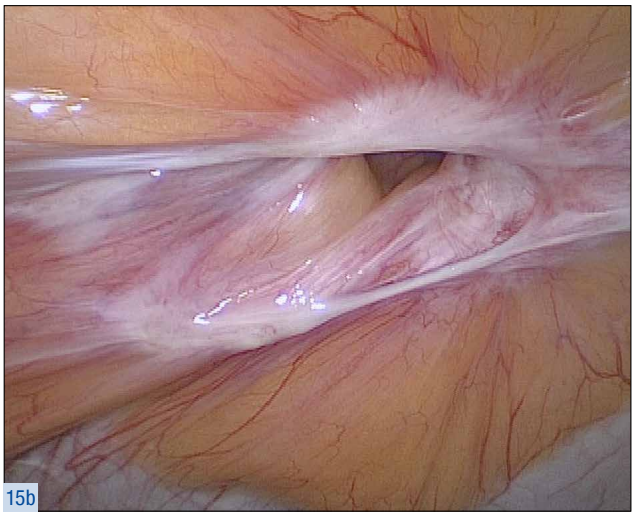
13b The pneumoperitoneum is created through a minilaparotomy.



14 The trocars should be placed an adequate distance from the fascial margin.



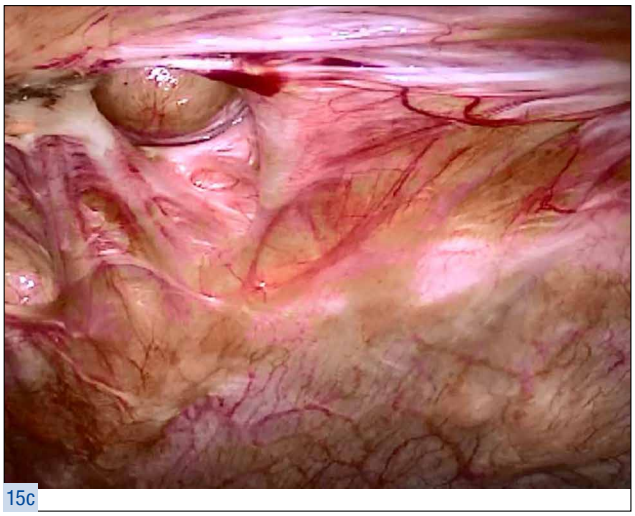
15a When carbon dioxide is insufflated, the adhesions usually come under tension and the plane of the dissection can be identified.



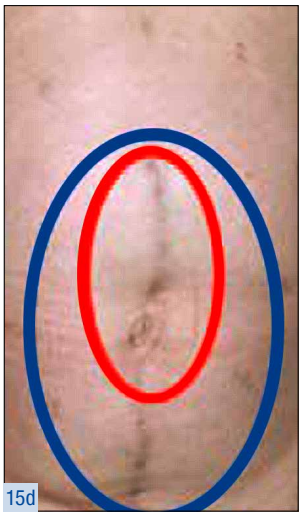
15b View of the hernia site upon completion of adhesiolysis.

The mesh should overlap the fascial margins by 4–5 cm on all sides. Corresponding points should be accurately marked on the mesh and on the abdominal wall. The other trocar sites – usually a total of 3–4 ports – are placed according to hernia location. They should always be placed an adequate distance from the fascial defect (Fig. 14). The use of a HOPKINS® rod-lens telescope with a 30° viewing angle is essential. The next step is to clear all adhesions from the anterior abdominal wall. Adhesiolysis is performed with a scissors (usually without electrocautery), but not with an ultrasonic scissors. Great care is taken to avoid thermal and mechanical injury to the bowel, and the procedure should be closely monitored for possible removal of serosa or iatrogenic bowel injuries. CO_2 insufflation will place tension on the adhesions, making it easier to identify the plane of the dissection (Fig. 15a).

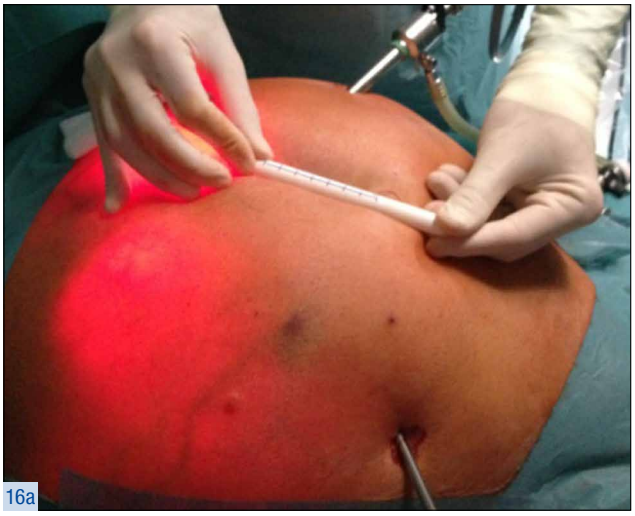
When all adhesions have been removed, the hernia site can be clearly visualized from within the abdomen (Fig. 15b). In some cases, additional smaller hernial defects may be seen along the course of the scar that were previously undetected by clinical examination. This underscores the need to cover the entire scar with mesh[122].



15c View of the abdominal hernia site following dissection.

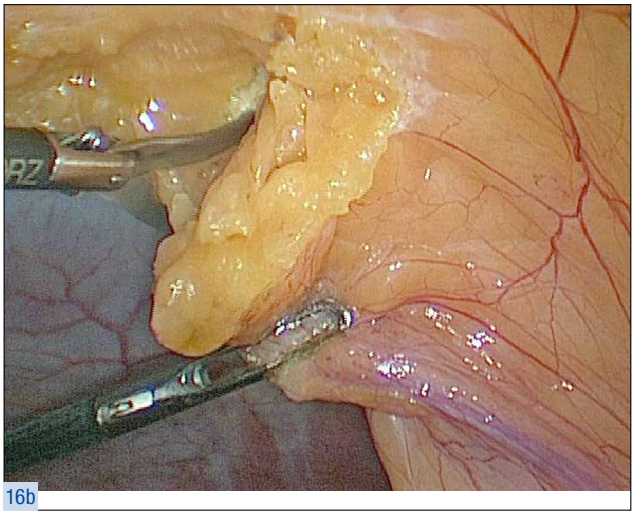


15d Area of herniation, (red). Entire area of the scar covered by the mesh (blue).



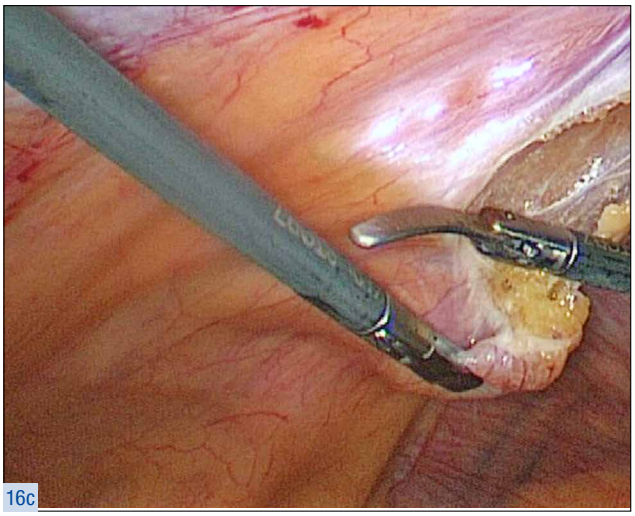
16a

Accurate measurement of the hernia defect.



16b

The falciform ligament is incised in a cranial direction.

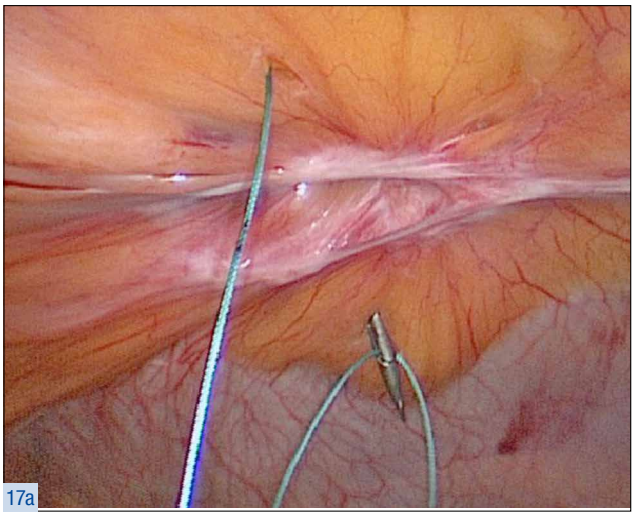


16c

Incision carried through the medial umbilical folds during dissection of the space of Retzius.

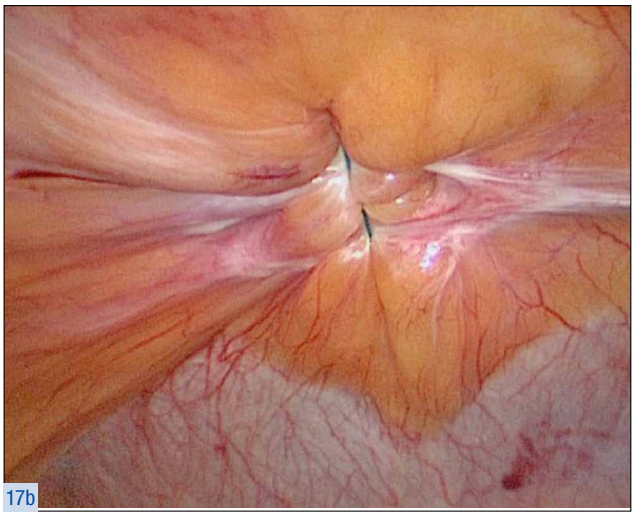
Next, the defect is precisely measured and marked on the abdominal skin. Extracorporeal anchoring sutures are attached to the marked positions ("cardinal points") (Figs. 18a, b; p. 22).

The final objective is to establish a reliable fixation of the mesh to the abdominal wall. This, in most cases, requires the falciform ligament to be incised in a cranial direction. Provided far caudal location of the hernia, the prevesical space (of Retzius) also needs to be included in pelvic dissection. This precautionary step provides adequate space anterior to the bladder to make sure that the mesh can be safely affixed to the adominal wall. Given a localized and well-circumscribed hernia, i.e., not a definite defect, the gap should be closed with an intracorporeal absorbable suture prior to mesh implantation (Fig. 17a, b). As a rule, this preemptive measure aids in improving the cosmetic outcome and appears to diminish the rate of seroma formation.



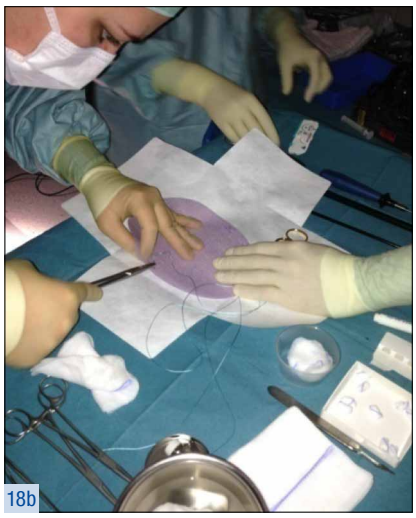
17a

Closure of a well-circumscribed hernia with an absorbable suture.

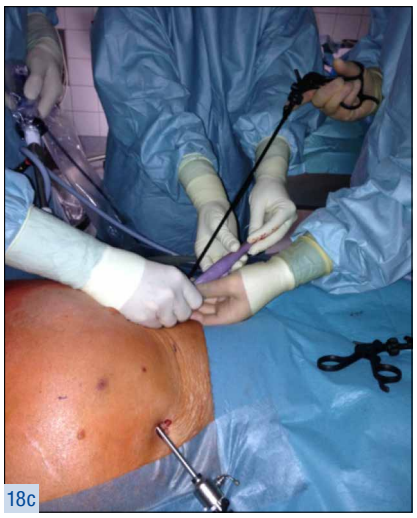


17b


18a

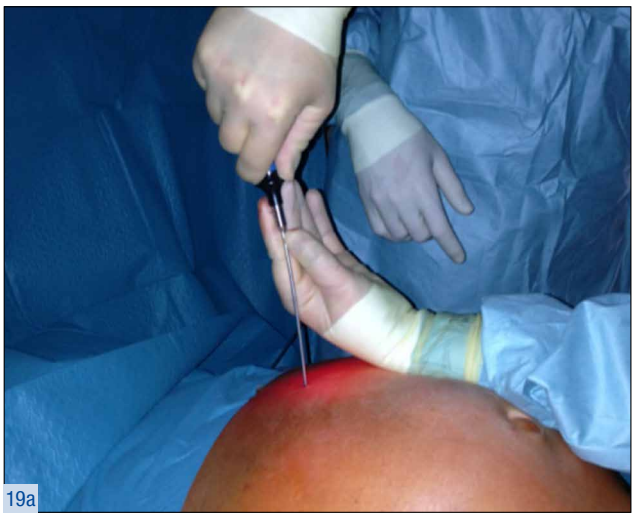

18b

Marking of the “cardinal points” on the mesh and fixation of anchoring sutures.

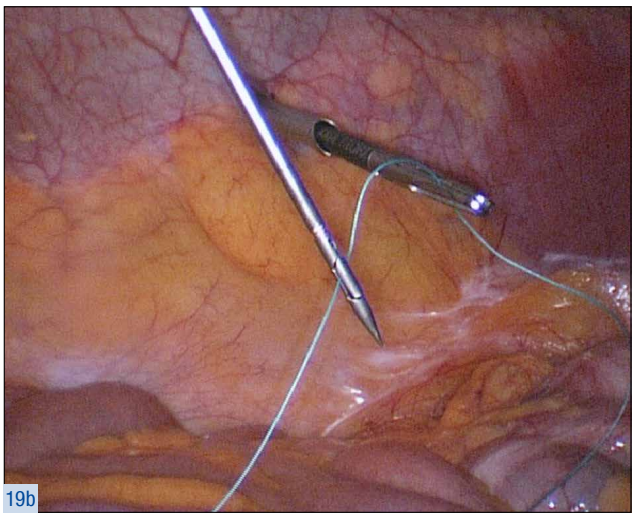

18c

Transabdominal passage of the mesh through a large-calibre trocar (12–15 mm).

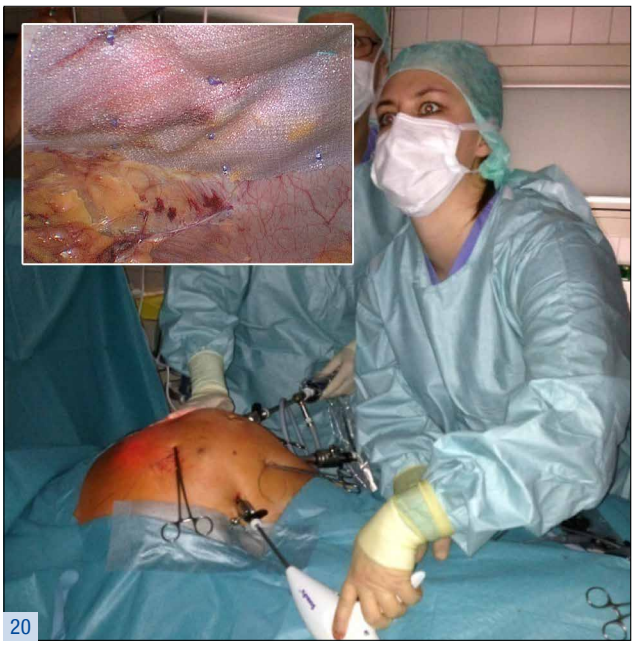
Non-absorbable sutures are preplaced outside the body – after proper marking of the “cardinal points” on the uncoated mesh surface (Fig. 18a, b).
At this stage of the operation, the implanted mesh is under slight tension beneath the abdominal wall, but after release of the pneumoperitoneum, the mesh will cover the fascial defect free of tension. The operation concludes with meticulous closure of the trocar sites. The authors routinely apply a stabilizing brace, that is worn for about 14 days postoperatively for seroma prophylaxis.


19a

Once the mesh has been completely unrolled within the abdomen, the sutures are brought out through the abdominal wall with a suture passer.

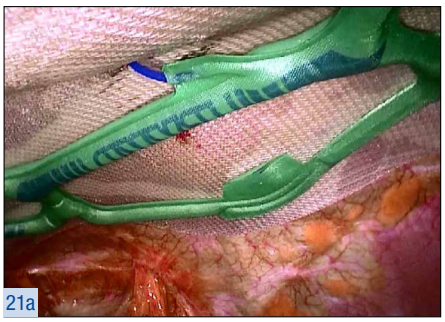

19b

Subsequently, the preplaced transfascial sutures are tied and buried in the subcutaneous plane.

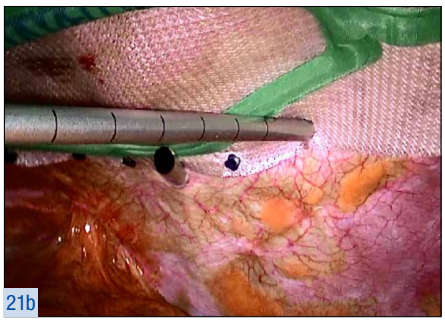


20

The mesh is definitively attached with absorbable tacks placed at 2-cm intervals along the mesh margin and along the palpable fascial margin employing the “double-crown” technique.



21a



21b

A new technique of mesh deployment is offered by C.R. Bard Inc. The use of a dedicated inflatable low-profile balloon facilitates a more rapid and crease-free positioning even of large-sized meshes and obviates the need for preplacement of anchoring sutures.

7.0 Laparoscopic Repair of Incisional Hernias in Obese Patients

Obesity is a special risk factor for the development of incisional hernias[1,10]. One reason for this is the need to use larger incisions in obese patients, leading to a higher rate of wound infection, and the greater frequency of comorbidity in this population[10,55].

Open hernia repairs in obese patients have up to a 50% recurrence rate due to the greater access trauma and the higher incidence of infection[55,89]. The laparoscopic technique was traditionally considered problematic in obese patients due to relatively poor intra-abdominal visualization and limited instrument ranges. The conversion rate was relatively high. In recent years, however, experience and instrument modifications based on laparoscopic obesity surgery have led to a reduction of postlaparoscopic complications in obese patients[89].

In an observational study by *Novitsky et al.* (2006) in 163 patients with incisional hernias and a high body mass index (BMI > 38), conversion to open surgery was necessary in only five of the patients who underwent laparoscopic hernia repair[89]. Complications arose in 12.3% of the patients: abdominal complaints lasting more than 6 months (3.7%), urinary tract infections (8.9%), pulmonary complications (2.5%), mesh infections (1.2%), one trocar hernia infection, and one infection with *Clostridium difficile*. No deaths occurred. The recurrence rate at two years was 5.5%[89].

Similar results were reported in a multicenter study by *Tsereteli* et al. (2008) in 134 patients with a BMI > 40 compared with 767 patients with a BMI < 40. During a mean follow-up of 19 months, the recurrence rate was 8.3% in the obese group versus 2.9% in the nonobese group. The conversion rate was slightly lower in the obese group (2.3% vs. 2.9%) and the average operating time was 35 minutes longer.

The authors conclude that laparoscopic incisional hernia repair is safe and feasible in morbidly obese patients and is associated with a higher but acceptable recurrence rate[123].

Incisional hernia operations in obese patients using laparoscopic technique have several special requirements that must be considered. These include open creation of the pneumoperitoneum, meticulous hemostasis, the lysis of adhesions without electrocautery, and a larger overlap of the abdominal defect (mesh size 600–800 cm^2)[89].

Weight reduction prior to incisional hernia repair is advisable and will lower the risk of recurrence. It might also be worthwhile to consider a bariatric procedure approximately 12–18 months before the hernia repair[89].

7.1 Conclusions

The results of the laparoscopic repair of incisional hernias with the aid of a dedicated mesh implant show that this technique is a valuable addition to the surgical armamentarium for the treatment of this condition[87]. With regard to tension-free positioning, the outcomes of laparoscopic mesh placement correspond to those obtained through a dorsal retromuscular mesh repair[4, 88]. This type of mesh placement appears to be favorable in terms of recurrence prevention and causes considerably less trauma to the abdominal wall. Using the laparoscopic technique, it is possible to repair a recurrent hernia with minimal trauma even after a previous conventional surgical approach. As a matter of course, patients with severe adhesions ("battlefield abdomen") must be excluded.

A laparoscopic treatment option should be considered by any surgeon faced with the decision-making as to which operative procedure be adopted.

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Recommended Set for Laparoscopic Repair of Incisional Hernias

Instruments, Units and Accessories

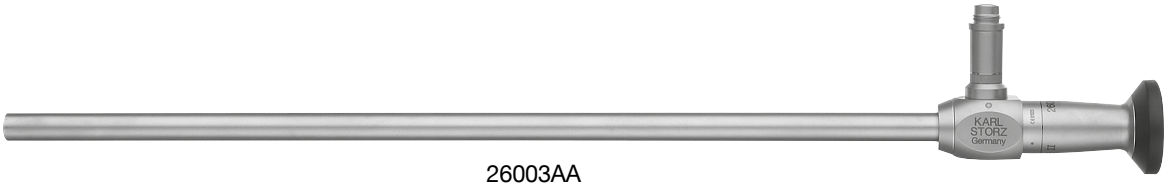
Laparoscopic Repair of Incisional Hernias – On the Treatment of Incisional Hernias

Recommended Instrument Set, Units and Accessories

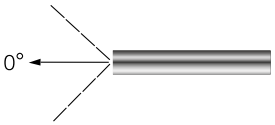
26003AA	**HOPKINS® Straight Forward Telescope 0°,** enlarged view, diameter 10 mm, length 31 cm, **autoclavable,** fiber optic light transmission incorporated, color code: green
26003BA	**HOPKINS® Forward-Oblique Telescope 30°,** enlarged view, diameter 10 mm, length 31 cm, **autoclavable,** fiber optic light transmission incorporated, color code: red
26003AE	**ENDOCAMELEON® HOPKINS® Telescope,** diameter 10 mm, length 32 cm, **autoclavable,** variable direction of view from 0°–120°, adjustment knob for selecting the desired direction of view, fiber optic light transmission incorporated, color code: gold
30160MP	3 x **Trocar,** with pyramidal tip, with insufflation stopcock, size 6 mm, working length 10.5 cm, color code: black, including: **Cannula,** without valve **Trocar only** **Multifunctional Valve**
30103MP	2 x **Trocar,** with pyramidal tip, with insufflation stopcock, size 11 cm, working length 10.5 cm, color code: green, including: **Cannula,** without valve **Trocar only** **Multifunctional Valvel**
30103AO	**Trocar,** size 11 mm, color code: green, including: **Trocar only,** with blunt tip **Cannula,** with 2 flanges for fixation of sutures, adjustable cone, with insufflation stopcock, working length 13 cm **Automatic Valve** **Cone** or
26120J	VERESS **Pneumoperitoneum Needle,** with spring-loaded blunt inner cannula, LUER-Lock, **autoclavable,** diameter 2.1 mm, length 10 cm
30140DB	**Reduction Sleeve,** reusable, instrument diameter 5 mm, trocar cannula outer diameter 11 mm, color code: green
30142HB	**Double Reducer,** 13/10 mm, 13.5/10 mm, 13/5 mm and 13.5/5 mm
33353ON	**CLICKLINE Grasping Forceps,** rotating, dismantling, insulated, with connector pin for unipolar coagulation, with LUER-Lock irrigation connector for cleaning, single action jaws, with fine atraumatic serration, fenestrated, size 5 mm, length 36 cm
33351ML	**CLICKLINE Dissecting and Grasping Forceps,** rotating, dismantling, insulated, with connector pin for unipolar coagulation, LUER-Lock connector for cleaning, double action jaws, long, size 5 mm, length 36 cm
33351DN	**CLICKLINE Dissecting and Grasping Forceps,** “dolphin nose”, rotating, dismantling, insulated, with connector pin for unipolar coagulation, with LUER-Lock irrigation connector for cleaning, double action jaws, size 5 mm, length 36 cm
33351DF	**CLICKLINE Dissecting and Grasping Forceps,** rotating, dismantling, insulated, with connector pin for unipolar coagulation, LUER-Lock connector for cleaning, double action jaws, atraumatic, size 5 mm, length 36 cm
33353CC	**CLICKLINE** CROCE-OLMI **Grasping Forceps,** rotating, dismantling, insulated, with connector pin for unipolar coagulation, with LUER-Lock irrigation connector for cleaning, single action jaws, atraumatic, fenestrated, curved, size 5 mm, length 36 cm
34351MA	**CLICKLINE Scissors,** rotating, dismantling, insulated, with connector pin for unipolar coagulation, with LUER-Lock irrigation connector for cleaning, double action jaws, spoon-shaped blades, serrated, curved, size 5 mm, length 36 cm
38651ON	**ROBI® Grasping Forceps,** CLERMONT-FERRAND model, rotating, dismantling, with connector pin for bipolar coagulation, with fine atraumatic serration, fenestrated jaws, double action jaws, size 5 mm, length 36 cm, color code: light blue
30173FAR	KOH **Macro Needle Holder,** dismantling, with LUER-Lock irrigation connector for cleaning, single action jaws, straight jaws, with tungsten carbide inserts, with axial handle, disengageable ratchet, ratchet position right, size 5 mm, length 33 cm
30173RAL	KOH **Macro Needle Holder,** dismantling, with LUER-Lock irrigation connector for cleaning, single action jaws, jaws curved to right, with tungsten carbide inserts, with axial handle, disengageable ratchet, ratchet position left, size 5 mm, length 33 cm
30173LAL	KOH **Macro Needle Holder,** dismantling, with LUER-Lock irrigation connector for cleaning, single action jaws, jaws curved to left, with tungsten carbide inserts, with axial handle, disengageable ratchet, ratchet position left, size 5 mm, length 33 cm
26173AM	BERCI **Fascial Closure Instrument,** for subcutaneous ligature of trocar incisions, size 2.8 mm, length 17 cm, for closure of trocar incision wounds

HOPKINS® Straight Forward Telescopes

Diameter 10 mm, length 31 cm

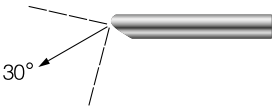


26003AA



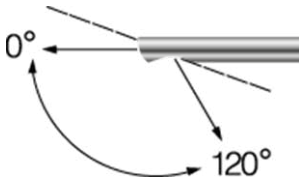
26003AA **HOPKINS® Straight Forward Telescope 0°,**
enlarged view, diameter 10 mm, length 31 cm,
autoclavable,
fiber optic light transmission incorporated,
color code: green

26003BA



26003BA **HOPKINS® Forward-Oblique Telescope 30°,**
enlarged view, diameter 10 mm, length 31 cm,
autoclavable,
fiber optic light transmission incorporated,
color code: red

26003AE



26003AE **ENDOCAMELEON® HOPKINS® Telescope,**
diameter 10 mm, length 32 cm, **autoclavable,**
variable direction of view from 0°–120°,
adjustment knob for selecting the desired direction of view,
fiber optic light transmission incorporated,
color code: gold

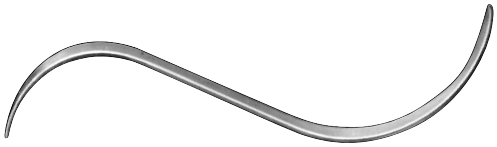
It is recommended to check the suitability of the product for the intended procedure prior to use.

Trocars and Accessories

size 11 mm

30103AO

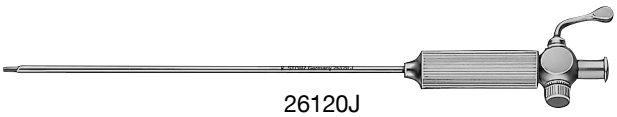
30103AO **Trocar,** size 11 mm, color code: green,
including:
Trocar only, with blunt tip
Cannula, with 2 flanges for fixation of sutures, adjustable cone, with insufflation stopcock, working length 13 cm
Automatic Valve
Cone



26031SO

26031SO **Retraktor,** S-förmig

VERESS **Pneumoperitoneum Needles**



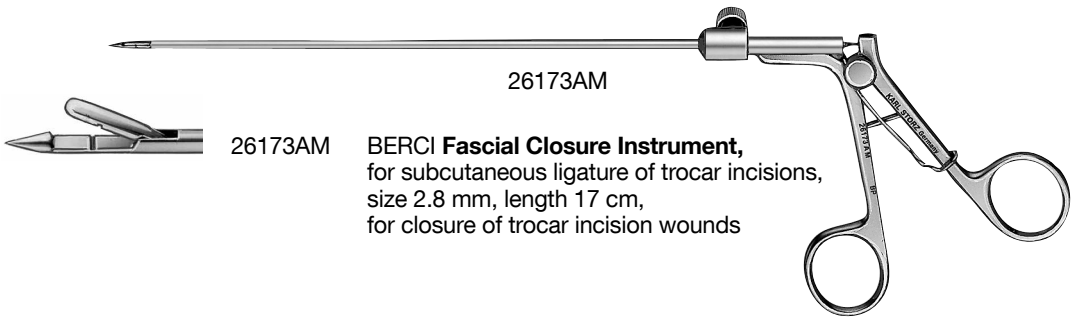
26120J

26120J VERESS **Pneumoperitoneum Needle,**
with spring-loaded blunt inner cannula, LUER-Lock,
autoclavable, diameter 2.1 mm, length 10 cm

26120JL **Same,** length 13 cm

BERCI **Fascial Closure Instrument**

for closure of trocar incision wounds

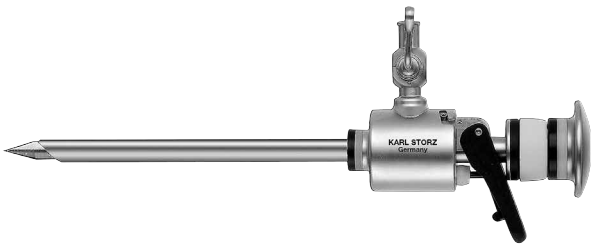


26173AM

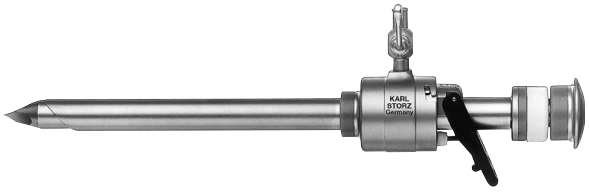
26173AM BERCI **Fascial Closure Instrument,**
for subcutaneous ligature of trocar incisions,
size 2.8 mm, length 17 cm,
for closure of trocar incision wounds

Trocars and Accessories

size 6, 11 and 13 mm



30160MP **Trocar,** with pyramidal tip,
with insufflation stopcock, size 6 mm,
working length 10.5 cm,
color code: black
including:
Cannula, without valve
Trocar only
Multifunctional Valve



30103MP **Trocar,** with pyramidal tip,
with insufflation stopcock, size 11 cm,
working length 10.5 cm,
color code: green
including:
Cannula, without valve
Trocar only
Multifunctional Valve

30107MP **Trocar,** with pyramidal tip,
with insufflation stopcock, size 13 mm,
working length 11.5 cm,
color code: black
including:
Cannula
Trocar only
Multifunctional Valve

30140DB **Reduction Sleeve,** reusable,
instrument diameter 5 mm, trocar cannula
outer diameter 11 mm, color code: green

30142HB **Double Reducer,**
13/10 mm, 13.5/10 mm, 13/5 mm
and 13.5/5 mm

Dissecting and Grasping Forceps

CLICKLINE – rotational, can be dismantled,
insulated, with connector pin for unipolar coagulation
Operating instrument, length 30, 36 and 43 cm, for use with trocars size 6 mm
Operating instrument, length 43 cm, for use with telescopes with inserted operating channel

Working Length				
30 cm				
36 cm				
43 cm	Handle 33151	Handle 33152	Handle 33153	Handle 33156

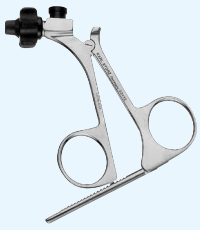
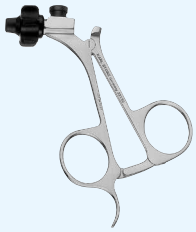
Double-action jaws

Insert No.	Catalog number of the complete instrument			
33210ML	33251ML	33252ML	33253ML	33256ML
33310ML	33351ML	33352ML	33353ML	33356ML
33410ML	33451ML	33452ML	33453ML	33456ML
 22	**CLICKLINE** KELLY **Dissecting and Grasping Forceps,** long			
33210DN	33251DN	33252DN	33253DN	33256DN
33310DN	33351DN	33352DN	33353DN	33356DN
33410DN	33451DN	33452DN	33453DN	33456DN
 18	**Dissecting and Grasping Forceps,** “Dolphin Nose”			
33210AF	33251AF	33252AF	33253AF	33256AF
33310AF	33351AF	33352AF	33353AF	33356AF
33410AF	33451AF	33452AF	33453AF	33456AF
 24	**CLICKLINE Grasping Forceps,** atraumatic, fenestrated			
33210DF	33251DF	33252DF	33253DF	33256DF
33310DF	33351DF	33352DF	33353DF	33356DF
33410DF	33451DF	33452DF	33453DF	33456DF
 17	**CLICKLINE Dissecting and Grasping Forceps,** atraumatic			

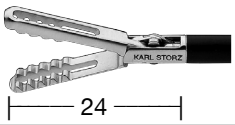
Please note:
For **CLICKLINE** nstruments only the **individual component parts** are numbered. The catalog number for the **complete instrument** is not on the instrument. Instruments with **insulated handles with connector** pin for unipolar coagulation, are shown against the **red** background. The colour **green** indicates the inserts.

Dissecting and Grasping Forceps

CLICKLINE – rotational, can be dismantled,
without connector pin for unipolar coagulation
Operating instrument, length 30, 36 and 43 cm, for use with trocars size 6 mm
Operating instrument, length 43 cm, for use with telescopes with inserted operating channel

Working Length				
30 cm				
36 cm				
43 cm	Handle 33132	Handle 33133	Handle 33141	Handle 33161

Double-action jaws

Insert No.	Catalog number of the complete instrument			
33210ML	33232ML	33233ML	33241ML	33261ML
33310ML	33332ML	33333ML	33341ML	33361ML
33410ML	33432ML	33433ML	33441ML	33461ML
 22	**CLICKLINE** KELLY **Dissecting and Grasping Forceps,** long			
33210DN	33232DN	33233DN	33241DN	33261DN
33310DN	33332DN	33333DN	33341DN	33361DN
33410DN	33432DN	33433DN	33441DN	33461DN
 18	**CLICKLINE Dissecting and Grasping Forceps,** “Dolphin Nose”			
33210AF	33232AF	33233AF	33241AF	33261AF
33310AF	33332AF	33333AF	33341AF	33361AF
33410AF	33432AF	33433AF	33441AF	33461AF
 24	**CLICKLINE Grasping Forceps,** atraumatic, fenestrated			
33210DF	33232DF	33233DF	33241DF	33261DF
33310DF	33332DF	33333DF	33341DF	33361DF
33410DF	33432DF	33433DF	33441DF	33461DF
 17	**CLICKLINE Dissecting and Grasping Forceps,** atraumatic			

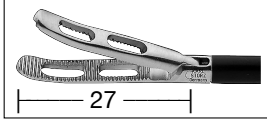
Please note:
For **CLICKLINE** instruments only the **individual component parts** are numbered. The catalog number for the **complete instrument** is not on the instrument. Instruments with **handles without connector** pin for unipolar coagulation are shown against the **blue** background. The colour **green** indicates the inserts.

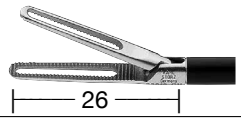
Grasping Forceps

CLICKLINE – rotational, can be dismantled,
insulated, with connector pin for unipolar coagulation
Operating instrument, length 30, 36 and 43 cm, for use with trocars size 6 mm
Operating instrument, length 43 cm, for use with telescopes with inserted operating channel

Working Length				
30 cm	 Handle 33151	 Handle 33152	 Handle 33153	 Handle 33156
36 cm				
43 cm				

Single-action jaw

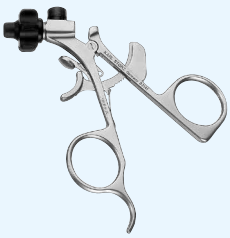
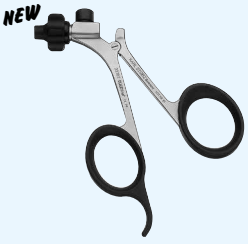
Insert No.	Catalog number of the complete instrument			
33210 CC	33251 CC	33252 CC	33253 CC	33256 CC
33310 CC	33351 CC	33352 CC	33353 CC	33356 CC
33410 CC	33451 CC	33452 CC	33453 CC	33456 CC
	**CLICKLINE** CROCE-OLMI **Grasping Forceps,** atraumatic, fenestrated, curved			

33210ON	33251ON	33252ON	33253ON	33256ON
33310ON	33351ON	33352ON	33353ON	33356ON
33410ON	33451ON	33452ON	33453ON	33456ON
	**CLICKLINE Grasping Forceps,** with fine atraumatic serration, fenestrated			

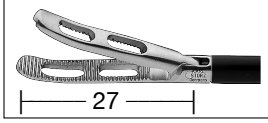
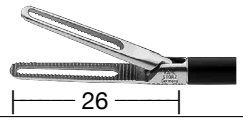
Please note:
For **CLICKLINE** nstruments only the **individual component parts** are numbered. The catalog number for the **complete instrument** is not on the instrument. Instruments with **insulated handles with connector** pin for unipolar coagulation, are shown against the **red** background. The colour **green** indicates the inserts.

Grasping Forceps

CLICKLINE – rotational, can be dismantled,
without connector pin for unipolar coagulation
Operating instrument, length 30, 36 and 43 cm, for use with trocars size 6 mm
Operating instrument, length 43 cm, for use with telescopes with inserted operating channel

Working Length	 Handle 33162	 Handle 33163	 Handle 33141	 Handle 33161
30 cm				
36 cm				
43 cm				

Single-action jaw

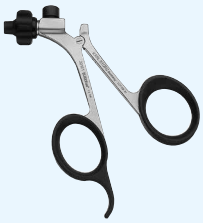
Insert No.	Catalog number of the complete instrument			
33210CC	33262CC	33263CC	33241CC	33261CC
33310CC	33362CC	33363CC	33341CC	33361CC
33410CC	33462CC	33463CC	33441CC	33461CC
	**CLICKLINE** CROCE-OLMI **Grasping Forceps,** atraumatic, fenestrated, curved			
33210ON	33262ON	33263ON	33241ON	33261ON
33310ON	33362ON	33363ON	33341ON	33361ON
33410ON	33462ON	33463ON	33441ON	33461ON
	**CLICKLINE Grasping Forceps,** with fine atraumatic serration, fenestrated			

Please note:
For **CLICKLINE** instruments only the **individual component parts** are numbered. The catalog number for the **complete instrument** is not on the instrument. Instruments with **handles without connector** pin for unipolar coagulation are shown against the **blue** background. The colour **green** indicates the inserts.

Scissors

CLICKLINE – rotational, can be dismantled,
with connector pin for unipolar coagulation
Operating instrument, length 30, 36 and 43 cm, for use with trocars size 6 mm
Operating instrument, length 43 cm, for use with telescopes with inserted operating channel

unipolar

Working Length	 Handle 33151	 Handle 33161
30 cm		
36 cm		
43 cm		

Single-action jaws

Insert No.	Catalog number of the complete instrument	
34210MS	34251MS	34261MS
34310MS	34351MS	34361MS
34410MS	34451MS	34461MS
 ⊢ 15 ⊣	**CLICKLINE** METZENBAUM **Scissors,** curved, length of blades 12 mm	

34210MA	34251MA	34261MA
34310MA	34351MA	34361MA
34410MA	34451MA	34461MA
 ⊢ 20 ⊣	**CLICKLINE Scissors,** with serrated jaws, curved, spoon blades, length of blades 17 mm	

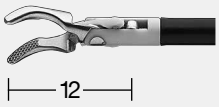
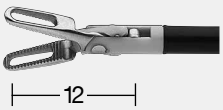
Please note:
For **CLICKLINE** instruments only the **individual component parts** are numbered. The catalog number for the **complete instrument** is not on the instrument. Instruments with **insulated handles with connector** pin for unipolar coagulation, are shown against the **red** background, instruments with **handles without connector** pin for unipolar coagulation are shown against the **blue** background. The colour **green** indicates the inserts.

ROBI® Bipolar rotational Instruments

Size 5 mm
Operating instruments, **length 36 cm,**
for use with trocars size 6 mm

bipolar

Outer Sheath	Handle
	38151
Length 36 cm	

Insert No.	Catalog number of the complete instrument
38610MD	38651MD
	**ROBI®** KELLY **Grasping Forceps,** CLERMONT-FERRAND model, with connector pin for bipolar coagulation, suitable for dissection, double-action jaws
38610ON	38651ON
	**ROBI® Grasping Forceps,** CLERMONT-FERRAND model, with connector pin for bipolar coagulation, with fine atraumatic serration, fenestrated, double action jaws
38610MW	38651MW
	**ROBI® Scissors,** CLERMONT-FERRAND model, with connector pin for bipolar coagulation, curved blades, double-action jaws

Surgical Sponge Holder

Size 5 mm
trocar size 6 mm

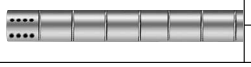
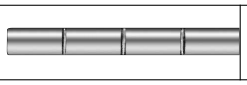
32340PT

32340PT **Surgical Sponge Holder,**
self-retaining, size 5 mm, length 30 cm
including:
Handle
Outer Sheath, insulated
Sponge Holder Insert

Irrigation and Suction Tubes

size 5 mm,
trocar size 6 mm

37360LH

Distal Tip	Working Length	Instrument No.	Description
	36 cm	37360LH	**Cannula,** with lateral holes
	43 cm	37460LH	
	36 cm	37360SC	**Cannula**

30805 **Handle with Two-Way Stopcock,**
for suction and irrigation, **autoclavable,**
for use with suction and irrigation tubes
sizes 3 and 5 mm

Knot Tier

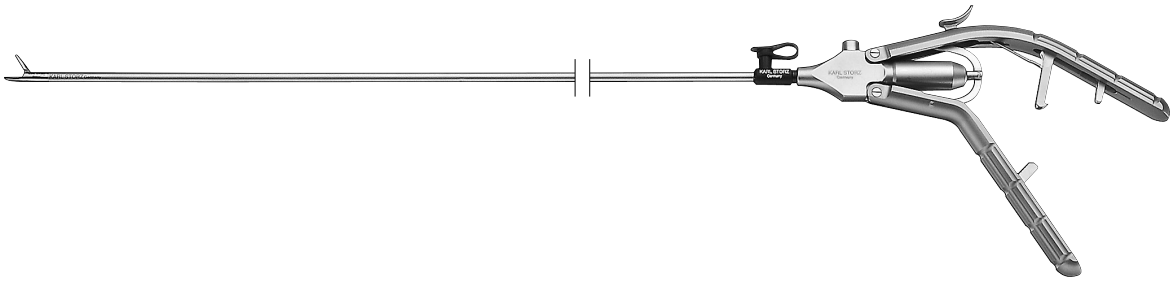
size 5 mm
trocar size 6 mm

26596SK

26596SK KÖCKERLING **Knot Tier,**
for extracorporeal knotting, size 5 mm, length 36 cm

KOH **Macro Needle Holder**

dismantable



KOH **Macro Needle Holder, size 5 mm, dismantling,**

including:

- **Handle**
- **Outer Sheath**
- **Working Insert**

Cleaning and sterilization are gaining increasing importance for KARL STORZ as a manufacturer of surgical instruments.

Similar to all our surgical instruments, the cleaning and hygiene of our needle holders also play an important role. For cleaning and sterilization, the KOH macro needleholders can be disassembled into its main components.

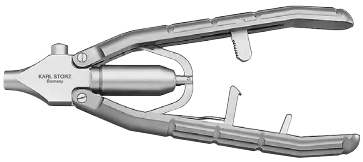
This unique reusable three-piece design offers the user the following benefits:

- **Can be disassembled into three separate components**
- **Autoclavable**
- **Cleaning adaptor**
- **Choice of six different handles and three different working inserts**
- **With tungsten carbide inserts**
- **In the event of damage, only the component with the defect needs to be replaced**

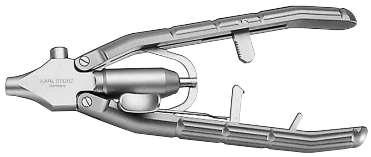
Handles and Outer Tubes

KOH **Macro Needle Holders, dismantable**

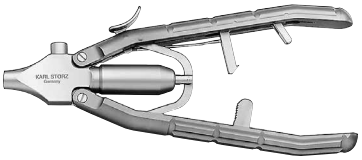
Handles axial and pistol grip with disengageable ratchet



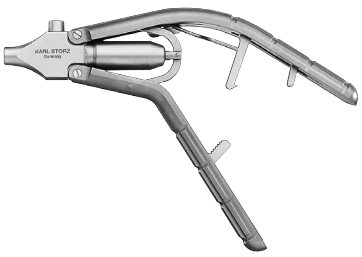
30173AR **Handle,** axial, with **disengageable** ratchet, ratchet release on the right side



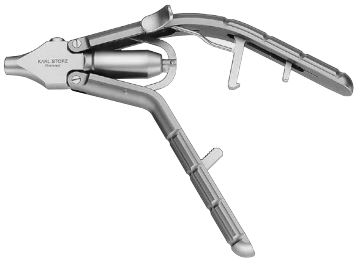
30173AL **Handle,** axial, with **disengageable** ratchet, ratchet release on the left side



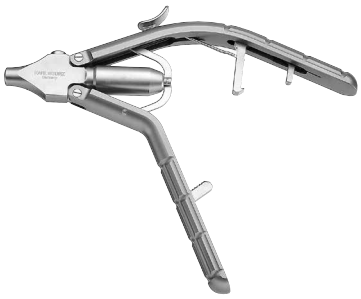
30173AO **Handle,** axial, with **disengageable** ratchet, ratchet release on top



30173PR **Handle,** pistol grip, with **disengageable** ratchet, ratchet release on the right side



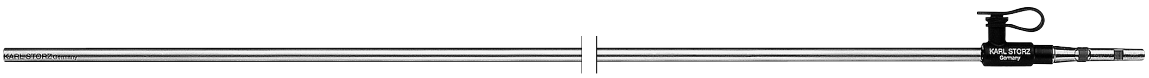
30173PL **Handle,** pistol grip, with **disengageable** ratchet, ratchet release on the left side



30173PO **Handle,** pistol grip, with **disengageable** ratchet, ratchet release on top

Metal Outer Sheath

Size 5 mm

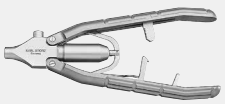
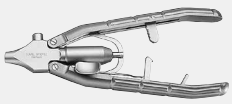
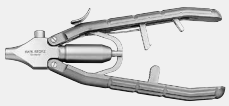


30173A

with LUER-Lock connector for cleaning	Length
30173 A	33 cm
30178 A	43 cm

KOH **Macro Needle Holder**
dismantable

Size 5 mm

Working Length	Handle		
	30173AR	30173AL	30173AO
33 cm			
43 cm			

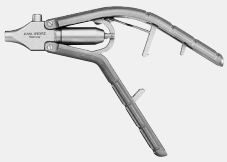
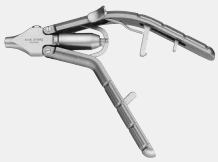
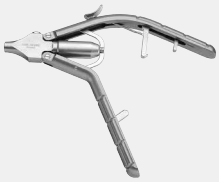
Single-action jaws

Insert No.	Complete Instrument		
30173R	30173RAR	30173RAL	30173RAO
30178R	30178RAR	30178RAL	30178RAO
	KOH **Macro Needle Holder,** dismantling, jaws curved to right, with tungsten carbide inserts, for use with suture material size 0/0 – 7/0		
30173L	30173LAR	30173LAL	30173LAO
30178L	30178LAR	30178LAL	30178LAO
	KOH **Macro Needle Holder,** dismantling, jaws curved to left, with tungsten carbide inserts, for use with suture material size 0/0 – 7/0		
30173F	30173FAR	30173FAL	30173FAO
30178F	30178FAR	30178FAL	30178FAO
	KOH **Macro Needle Holder,** dismantling, straight jaws, with tungsten carbide inserts, for use with suture material size 0/0 – 7/0		

KOH **Macro Needle Holder**

dismantable

Size 5 mm

Working Length	Handle		
	30173PR	30173PL	30173PO
33 cm			
43 cm			

Single-action jaws

Insert No.	Complete Instrument		
30173R	30173RPR	30173RPL	30173RPO
30178R	30178RPR	30178RPL	30178RPO
	KOH **Macro Needle Holder,** dismantling, jaws curved to right, with tungsten carbide inserts, for use with suture material size 0/0 – 7/0		
30173L	30173LPR	30173LPL	30173LPO
30178L	30178LPR	30178LPL	30178LPO
	KOH **Macro Needle Holder,** dismantling, jaws curved to left, with tungsten carbide inserts, for use with suture material size 0/0 – 7/0		
30173F	30173FPR	30173FPL	30173FPO
30178F	30178FPR	30178FPL	30178FPO
	KOH **Macro Needle Holder,** dismantling, straight jaws, with tungsten carbide inserts, for use with suture material size 0/0 – 7/0		

Mobile Equipment Cart

Monitor:

9627NB	**27" FULL HD Monitor**

Camera System:

TC200DE	**IMAGE1 S CONNECT**, connect module
TC300	**IMAGE1 S H3-LINK**, link module
TH100	**IMAGE1 S H3-Z** **Three-Chip FULL HD Camera Head**

Light Source:

20133101-1	**XENON 300 SCB Cold Light Fountain**
495NCSC	**Fiber Optic Light Cable**

HF-Device:

20535201-125	**AUTOCON® II 400**
20017830	**Two-Pedal Footswitch**

Insufflation:

UI400S1	**ENDOFLATOR® 40**
UP501S3	**S-PILOT™**

Pump System:

26331101-1	HAMOU® **ENDOMAT®**

Equipment Cart:

UG120	**COR™ Equpiment Cart,** narrow, high
UG500	**Monitor Holder**
UG609	**Bottle Holder,** for CO_2-Bottles
29005DFH	**Foot-Pedal Holder,** for Two- and Three-Pedal Footswitches
UG310	**Isolation Transformer,** 200 V–240 V
UG410	**Earth Leakage Monitor,** 200 V–240 V

IMAGE1 S Camera System NEW

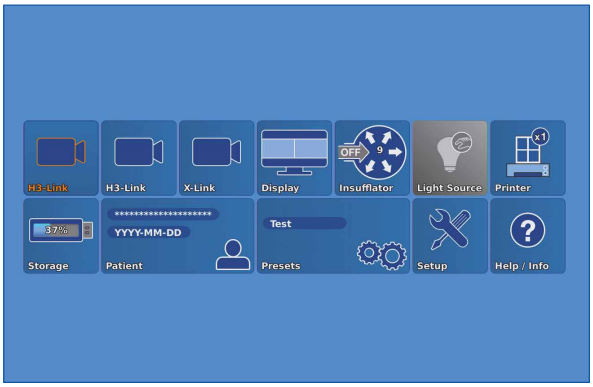
IMAGE1 S

Economical and future-proof

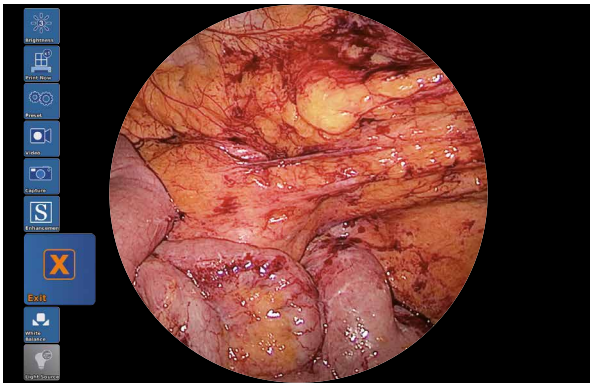
- Modular concept for flexible, rigid and 3D endoscopy as well as new technologies
- Forward and backward compatibility with video endoscopes and FULL HD camera heads
- Sustainable investment
- Compatible with all light sources

Innovative Design

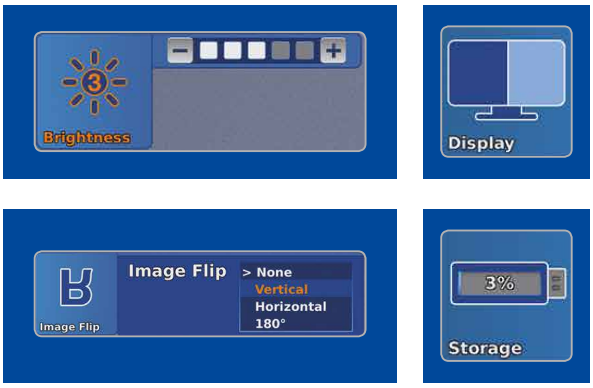
- Dashboard: Complete overview with intuitive menu guidance
- Live menu: User-friendly and customizable
- Intelligent icons: Graphic representation changes when settings of connected devices or the entire system are adjusted
- Automatic light source control
- Side-by-side view: Parallel display of standard image and the Visualization mode
- Multiple source control: IMAGE1 S allows the simultaneous display, processing and documentation of image information from two connected image sources, e.g., for hybrid operations



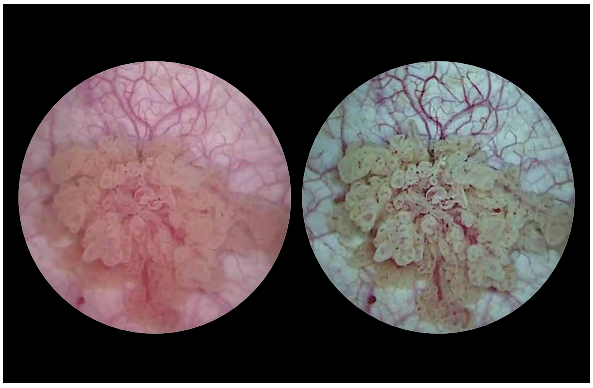
Dashboard



Live menu



Intelligent icons

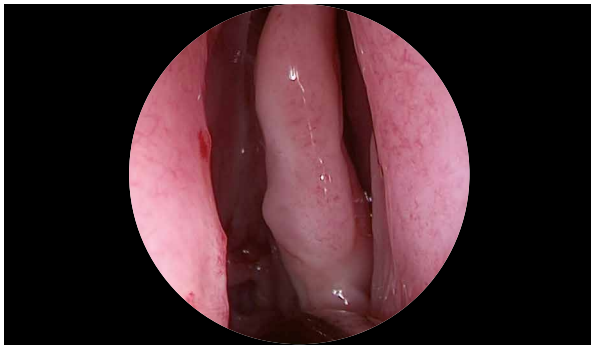


Side-by-side view: Parallel display of standard image and Visualization mode

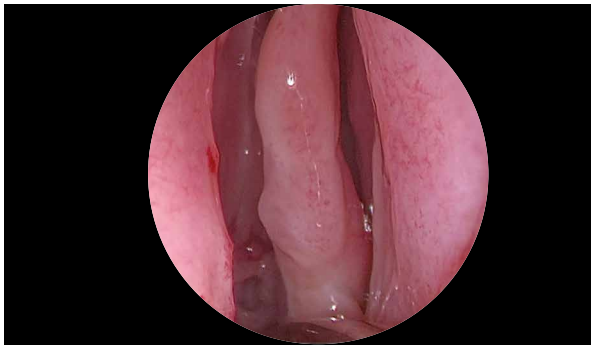
IMAGE1 S Camera System

Videoendoscopic Imaging

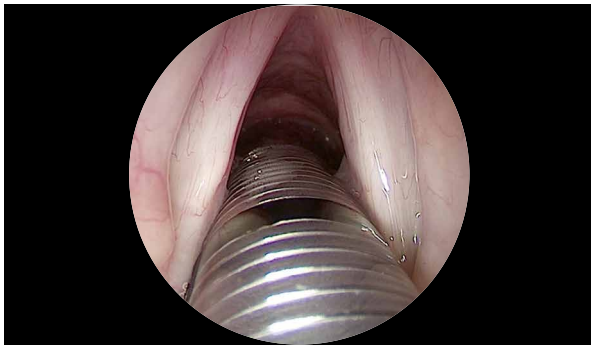
- **Very high quality of endoscopic images in FULL HD**
- **Natural color rendition**
- **Multiple IMAGE1 S technologies for homogeneous illumination, contrast enhancement and color shifting**



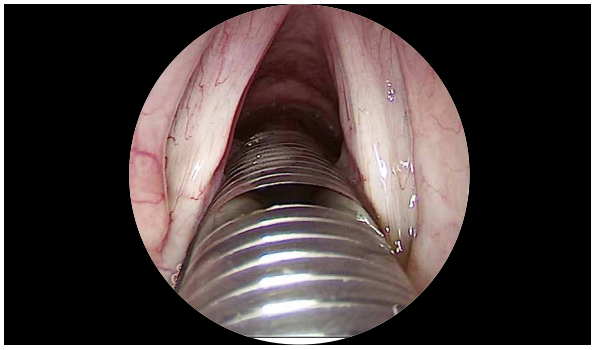
FULL HD image



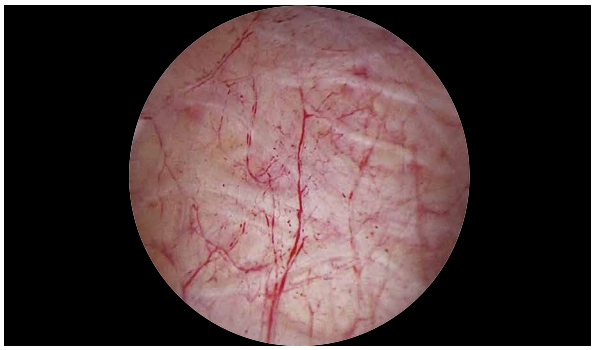
CLARA



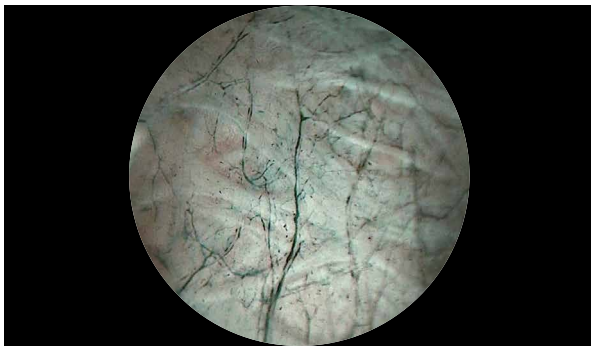
FULL HD image



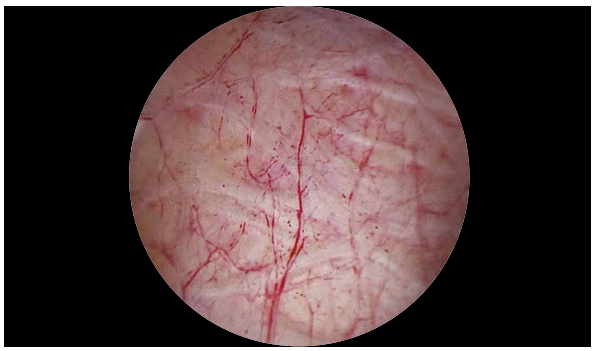
CHROMA



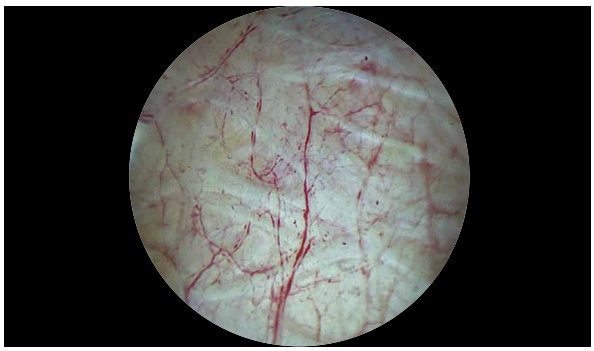
FULL HD image



*SPECTRA A**



FULL HD image



*SPECTRA B***

* *SPECTRA A:* **Not for sale in the U.S.**
** *SPECTRA B:* **Not for sale in the U.S.**

IMAGE1 S Camera System

TC200EN

TC200EN* **IMAGE1 S CONNECT**, connect module, for use with up to 3 link modules, resolution 1920 x 1080 pixels, with integrated KARL STORZ-SCB and digital Image Processing Module, power supply 100–120 VAC/200–240 VAC, 50/60 Hz
including:
Mains Cord, length 300 cm
DVI-D Connecting Cable, length 300 cm
SCB Connecting Cable, length 100 cm
USB Flash Drive, 32 GB, USB silicone keyboard, with touchpad, US
***Available in the following languages:** DE, ES, FR, IT, PT, RU

Specifications:

HD video outputs	- 2x DVI-D - 1x 3G-SDI
Format signal outputs	1920 x 1080p, 50/60 Hz
LINK video inputs	3x
USB interface SCB interface	4x USB, (2x front, 2x rear) 2x 6-pin mini-DIN

Power supply	100–120 VAC/200–240 VAC
Power frequency	50/60 Hz
Protection class	I, CF-Defib
Dimensions w x h x d	305 x 54 x 320 mm
Weight	2.1 kg

For use with IMAGE1 S
IMAGE1 S CONNECT Module TC200EN

TC300

TC300 **IMAGE1 S H3-LINK,** link module, for use with IMAGE1 FULL HD three-chip camera heads, power supply 100–120 VAC/200–240 VAC, 50/60 Hz, **for use with IMAGE1 S CONNECT TC 200EN**
including:
Mains Cord, length 300 cm
Link Cable, length 20 cm

Specifications:

Camera System	**TC300 (H3-Link)**
Supported camera heads/video endoscopes	TH100, TH101, TH102, TH103, TH104, TH106 (fully compatible with IMAGE1 S) 22220055-3, 22220056-3, 22220053-3, 22220060-3, 22220061-3, 22220054-3, 22220085-3 (compatible without IMAGE1 S technologies CLARA, CHROMA, SPECTRA*)
LINK video outputs	1x
Power supply	100–120 VAC/200–240 VAC
Power frequency	50/60 Hz
Protection class	I, CF-Defib
Dimensions w x h x d	305 x 54 x 320 mm
Weight	1.86 kg

* *SPECTRA A:* **Not for sale in the U.S.**
** *SPECTRA B:* **Not for sale in the U.S.**

IMAGE1 S Camera Heads

For use with IMAGE1 S Camera System
IMAGE1 S CONNECT Module TC200EN, IMAGE1 S H3-LINK Module TC300
and with all IMAGE1 HUB™ HD Camera Control Units

TH100

TH100 **IMAGE1 S H3-Z Three-Chip FULL HD Camera Head,** 50/60 Hz, IMAGE1 S compatible, progressive scan, soakable, gas- and plasma-sterilizable, with integrated Parfocal Zoom Lens, focal length f = 15–31 mm (2x), 2 freely programmable camera head buttons, for use with IMAGE1 S and IMAGE1 HUB™ HD/HD

Specifications:

IMAGE1 FULL HD Camera Heads	IMAGE1 S H3-Z
Product no.	TH100
Image sensor	3x ⅓" CCD chip
Dimensions w x h x d	39 x 49 x 114 mm
Weight	270 g
Optical interface	integrated Parfocal Zoom Lens, f = 15–31 mm (2x)
Min. sensitivity	F 1.4/1.17 Lux
Grip mechanism	standard eyepiece adaptor
Cable	non-detachable
Cable length	300 cm

TH104

TH104 **IMAGE1 S H3-ZA Three-Chip FULL HD Camera Head,** 50/60 Hz, IMAGE1 S compatible, **autoclavable,** progressive scan, soakable, gas- and plasma-sterilizable, with integrated Parfocal Zoom Lens, focal length f = 15–31 mm (2x), 2 freely programmable camera head buttons, for use with IMAGE1 S and IMAGE1 HUB™ HD/HD

Specifications:

IMAGE1 FULL HD Camera Heads	IMAGE1 S H3-ZA
Product no.	TH104
Image sensor	3x ⅓" CCD chip
Dimensions w x h x d	39 x 49 x 100 mm
Weight	299 g
Optical interface	integrated Parfocal Zoom Lens, f = 15–31 mm (2x)
Min. sensitivity	F 1.4/1.17 Lux
Grip mechanism	standard eyepiece adaptor
Cable	non-detachable
Cable length	300 cm

Monitors

9619NB

9619NB **19" HD Monitor,**
color systems **PAL/NTSC,** max. screen resolution 1280 x 1024, image format 4:3, power supply 100–240 VAC, 50/60 Hz, wall-mounted with VESA 100 adaption, including:
External 24 VDC Power Supply
Mains Cord

9826NB

9826NB **26" FULL HD Monitor,**
wall-mounted with VESA 100 adaption, color systems **PAL/NTSC,**
max. screen resolution 1920 x 1080, image fomat 16:9,
power supply 100–240 VAC, 50/60 Hz including:
External 24 VDC Power Supply
Mains Cord

Monitors

KARL STORZ HD and FULL HD Monitors	19"	26"
Wall-mounted with VESA 100 adaption	9619NB	9826NB
Inputs:		
DVI-D	●	●
Fibre Optic	–	–
3G-SDI	–	●
RGBS (VGA)	●	●
S-Video	●	●
Composite/FBAS	●	●
Outputs:		
DVI-D	●	●
S-Video	●	–
Composite/FBAS	●	●
RGBS (VGA)	●	–
3G-SDI	–	●
Signal Format Display:		
4:3	●	●
5:4	●	●
16:9	●	●
Picture-in-Picture	●	●
PAL/NTSC compatible	●	●

Optional accessories:

9826SF **Pedestal,** for monitor 9826NB
9626SF **Pedestal,** for monitor 9619NB

Specifications:

KARL STORZ HD and FULL HD Monitors	19"	26"
Desktop with pedestal	optional	optional
Product no.	9619NB	9826NB
Brightness	200 cd/m² (typ)	500 cd/m² (typ)
Max. viewing angle	178° vertical	178° vertical
Pixel distance	0.29 mm	0.3 mm
Reaction time	5 ms	8 ms
Contrast ratio	700:1	1400:1
Mount	100 mm VESA	100 mm VESA
Weight	7.6 kg	7.7 kg
Rated power	28 W	72 W
Operating conditions	0–40°C	5–35°C
Storage	-20–60°C	-20–60°C
Rel. humidity	max. 85%	max. 85%
Dimensions w x h x d	469.5 x 416 x 75.5 mm	643 x 396 x 87 mm
Power supply	100–240 VAC	100–240 VAC
Certified to	EN 60601-1, protection class IPX0	EN 60601-1, UL 60601-1, MDD93/42/EEC, protection class IPX2

Cold Light Fountains and Accessories

For use with telescopes, diameter 10 mm:

495NCSC **Fiber Optic Light Cable,**
with straight connector, extremely heat-resistant, safety lock, diameter 4.8 mm, length 250 cm

For use with telescopes, diameter 5 mm:

495NAC **Fiber Optic Light Cable,**
with straight connector, extremely heat-resistant, with safety lock, increased light transmission, diameter 3.5 mm, length 230 cm,
can be used for ICG applications

Cold Light Fountain XENON 300 SCB

20133101-1 **Cold Light Fountain XENON 300 SCB**
with built-in antifog air-pump, and integrated KARL STORZ Communication Bus System SCB
power supply:
100–125 VAC/220–240 VAC, 50/60 Hz
including:
Mains Cord
SCB Connecting Cable, length 100 cm

20133027 **Spare Lamp Module XENON**
with heat sink, 300 watt, 15 volt

20133028 **XENON Spare Lamp,** only,
300 watt, 15 volt

Cold Light Fountain XENON NOVA® 300

20134001 **Cold Light Fountain XENON NOVA® 300,**
power supply:
100–125 VAC/220–240 VAC, 50/60 Hz
including:
Mains Cord

20133028 **XENON Spare Lamp,** only,
300 watt, 15 volt

THERMOFLATOR® with KARL STORZ SCB

with High Flow Insufflation (30 l/min.)

* mtp

26 4320 08-1 **THERMOFLATOR® SCB**
including:
THERMOFLATOR® with KARL STORZ SCB
power supply 100–240 VAC, 50/60 Hz
Mains Cord
OPTITHERM® Heating Element, sterilizable
Silicone Tubing Set, sterilizable
Universal Wrench
SCB Connecting Cable, length 100 cm
* **CO_2/N_2O Gas Filter,** sterile,
for single use, package of 10

Subject to t-he customer's application-specific requirements additional accessories must be ordered separately.

HAMOU® **ENDOMAT®** with KARL STORZ SCB

Suction and Irrigation System

* mtp

26331101-1 HAMOU® **ENDOMAT® SCB,**
power supply 100–240 VAC, 50/60 Hz
including:
Mains Cord
5x **HYST Tubing Set*,** for single use
5x **LAP Tubing Set*,** for single use
SCB Connecting Cable, length 100 cm
VACUsafe Promotion Pack Suction*, 2 l

Subject to the customer's application-specific requirements additional accessories must be ordered separately.

Notes