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ORIGINAL ARTICLE

Comparison of biological and alloplastic meshes in ventral incisional hernia repair

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Abstract

Purpose The aim of our retrospective analysis was to compare the results of incisional hernia repair by porcine small intestinal submucosa-derived (SIS) meshes with those obtained by alloplastic polypropylene-based (PP) meshes in comparable surgical indications by matched-pair design. We hypothesized that in incisional hernia, SIS mesh repair is associated with fewer recurrences and SSO than PP mesh repair in incisional hernias.

Methods Twenty-four matched pairs (SIS vs. PP mesh repair between 1 January 2005 and 31 December 2013) were identified by matching criteria: gender, age, comorbidities, body mass index, EHS hernia classification, mesh implantation technique, CDC wound classification, and source of contamination/primary surgery leading to incisional hernia. Minimal follow-up time was 24 months. Means and standard deviations were compared by paired *t* test; categorial data were compared by McNemar's test. Poisson's distribution and negative binominal distribution were employed to detect significant correlation.

Results There were no statistically significant differences between both groups in the pre- and perioperative factors and the follow-up times. There were significantly more wound complications (19 vs. 12, $p = 0.041$), longer hospital stay (22.0 ± 6.3 vs. 12.0 ± 3.1 days, $p = 0.010$), and significantly more recurrent hernias (25 vs. 12.5%, $p = 0.004$) after SIS mesh repair. Both the Poisson's distribution and the negative binominal distribution unveiled significantly more complication points (3–6 vs. 1–2) per month after SIS mesh repair.

Conclusion There is no advantage of SIS meshes compared to PP meshes in incisional hernia repair with different degrees of wound contamination in this matched-pair analysis. Further prospective and randomized trials or at least registry studies such as the EHS register with standardized and defined conditions are warranted.

Keywords Ventral incisional hernia · Biologic mesh · Alloplastic mesh · Cross-matched pair

Introduction

Incisional hernias are the most common complication of abdominal operations with an incidence of 20% within 10 postoperative years. Given 700,000 laparotomies performed in Germany per year, 140,000 new incisional hernias per year could be expected. [1] The current practice of incisional hernia repair employing alloplastic meshes has been achieving satisfying results. [2] Limits of this procedure are chronic inflammatory responses and foreign body reactions leading to degradation of mesh material, postoperative pains, and abnormal development of scar tissue. [3, 4] According to Robinson et al. [5], each alloplastic mesh can show distinct complications such as seromas, infections, adhesions, and erosions of adjacent organs. Alloplastic meshes should be avoided in contaminated or infected operative sites. [3, 4] In 50 to 90% of such cases, the complications were so severe that the mesh had to be explanted. [6] In the early years of this century, biological meshes were developed from animal or human tissues. [4] Those biological meshes were reported to have more favorable physical and mechanic features and less mesh-related

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complications than alloplastic meshes. Additionally, they may be implanted in a contaminated or infected operative site. However, the host's body reaction to the biological mesh remains unpredictable. Beside the intended colonization by host's fibroblasts and establishment of new metabolically active tissues within the mesh, complete resorption and encapsulation of the biological mesh has been observed. [4, 7] Although several animal studies and clinical trials could demonstrate the successful use of biological meshes [8], only few trials have been published comparing the alloplastic and biological meshes employed in comparable situations. [3, 9, 10] The published results have to be considered with respect to each different biological material and are, therefore, heterogeneous. [8] Since biological meshes are still much more expensive than alloplastic meshes and have provided little evidence for their clinical use, their advantages have yet to be shown both for their suitability in certain surgical applications and in independent clinical trials. Up to now, most available studies on biological meshes have been related to any particular mesh and are applicational studies. Most recently, few retrospective studies have been presented comparing a distinct biological mesh with alloplastic mesh in similar situations. [8–10] Among biological meshes derived from animal or human dermis, porcine small intestinal submucosa-derived (SIS) meshes stand out because of their material. They have also been employed in inciscional hernia repair with comparable results. Gupta et al. published the only trial comparing SIS mesh with human acellular dermal matrix, but not with alloplastic material. [11–13]

The aim of our retrospective analysis was to compare the results of incisional hernia repair by SIS-meshes with those by polypropylene-based (PP) meshes in comparable surgical indications by matched-pair design. We hypothesized that SIS mesh repair is associated with fewer recurrences and SSI than PP mesh repair in incisional hernias.

Material and methods

SIS meshes were implanted in 26 of our patients with incisional hernias from 01 July 2009 to 31 December 2013. We have been implanting biological meshes since 01 July 2009. In contrast, a total of 326 patients had received PP meshes for incisional hernia repair at our department in the period from 01 January 2005 to 31 December 2013. From this PP group, 26 patients were chosen for our retrospective matched-pair analysis to compare the results of SIS mesh and PP mesh in incisional hernia repair. We included all patients aged over 18 years who had been operated on inicisional or recurrent incisional hernias between 01 January 2005 and 31 December 2013, and received a PP or SIS mesh for incisional hernia repair. Thus, we could include 187 of the 352 patients in our study. Exclusion criteria were abdominal wall closure by resorbable meshes, actual compromised soft tissue coverage, and incomplete data documentation (flow chart for patients selection: Fig. 1). Data acquisition was performed retrospectively by electronical patients documentation (KAS based on SAP) and the paper charts. Collected data of the 187 included patients contained age, sex, body height and weight, duration of hospital stay, classification and width according to European Hernia Society (EHS) [14], emergency or elective hernia repair, suture material, technique of hernia repair, perioperative complications of hernia repair, time between primary laparotomy and hernia occurrence, incisional or recurrent incisional hernia, preoperative risk factors (comorbidities such as chronic pulmonary disease, obesity, smoking, diabetes mellitus, disorders of connective tissue, cardiac diseases, intake of steroids and immunosuppressives, anemia), mesh material, mesh overlap at fixation site, fixation technique, mesh implantation technique, postoperative complications such as surgical site infections (SSI), surgical site occurrences (SSO: hematoma, seroma, soft tissue necrosis) [15, 16], incisional hernia recurrence, enduring pains at operative site, mesh complications, and need for early mesh explantation.

The 26 patients after SIS mesh repair were compared with 26 patients after PP mesh repair by matched-pair design using 8 matching criteria: gender, age, similar profile of comorbidities as mentioned above, body mass index, hernia classification according to EHS, mesh implantation technique, CDC wound class [15], and source of potential contamination/primary surgery performed (Tables 1 and 2). Patients were only matched if they most closely corresponded to the respective partner in all eight criteria. Twenty-four matched pairs could be identified. Patients with SIS mesh repair form study group 1 and patients with PP mesh repair form study group 2. The follow-up was finished on 31 December 2015 warranting a minimal follow-up time of 24 months. There has been implemented a regular clinical follow-up visit program for hernias in our department for about 10 years. Within the first two postoperative years, patients have been seen not later than 30 days, 6 months, 12 months, and 24 months after hernia repair. Visits were held more frequently between these intervals if postoperative complications occurred. Diagnosis of incisional hernia was made by clinical exam and confirmed by ultrasound and/or by CT scanning.

There were no significant differences between both groups in patient characteristics and perioperative data (Tables 1 and 2). In group 1, 24 patients received porcine non-cross-linked intestinal submucosa-derived meshes (Surgisis Biodesign® meshes (Cook Medical)). The indications for use of biologic mesh included potential bacterial contamination, direct placement of mesh over the intraabdominal organs, and presumed compromised soft tissue coverage. In group 2 of our study, we implanted 24 polypropylene-based meshes (12 Ultrapro® meshes (Ethicon, Johnson&Johnson Medical), 12 Vypro®

Table 1 Patient characteristics for biologic versus alloplastic mesh repair

	Biologic (n = 24)	Alloplastic (n = 24)	Significance
Demographics			
Age (years)	58 ± 9.3 (95% CI 52.7–62.5)	60 ± 9.9 (95%-CI 53.3–64.8)	n.s., p = 0.107 (difference of means − 2.1 (95% CI − 6.98–0.73)
Men/women	14/10	14/10	N/A (matched pairs)
ASA score	II, 11 III, 13	II, 12 III, 12	n.s., p = 0.611
BMI (kg/m^2)	26.9 ± 5.7 (95% CI 21.4–29.6)	27.2 ± 4.7 (95% CI 24.6–30.3)	n.s., p = 0.905 (difference of means − 0.36 (95% CI − 8.19–7.47)
BMI > 30 kg/m^2	10 (41.7%)	10 (41.7%)	N/A (matched pairs)
Comorbidities			
Hypertension	12 (50.0%)	12 (50.0%)	
Diabetes	6 (25.0%)	6 (25.0%)	
Smoker	11 (45.8%)	11 (45.8%)	
COPD	8 (33.3%)	8 (33.3%)	
Immunosuppressants	5 (20.8%)	5 (20.8%)	
Hernia characteristics			N/A (matched pairs)
Recurrent incisional hernia	11 (45.8%)	11 (45.8%)	
Incarceration	None	None	
Prior mesh implantation	7	7	
Surgery prior to hernia			
Sigma removal for perforated sigmoid diverticulitis	6	5	
Hemicolectomy for colorectal cancer	2	2	
Anterior rectum resection for cancer	2	4	
Colectomy for CED	2	1	
Gastric surgery for perforated ulcera	1	1	
Necrotising pancreatitis	3	3	
Laparotomy for ovarian cancer	2	2	
Liver transplantation	4	4	
Infrarenal abdominal aortic aneurysm	2	1	
Aortobifemoral bypass for vascular occlusive disease	–	1	

meshes (Ethicon, Johnson&Johnson)). The choice of the type of mesh was left to the surgeon's discretion. The indications for use of biologic mesh included potential bacterial contamination, direct placement of mesh over the intraabdominal organs, and presumed compromised but not realized soft tissue coverage.

Statistical analysis was performed by means of the GraphPad Prism7 Software and IBM© SPSS© Statistics 22 program and STATA® Release 12 for windows. Means and standard deviations were compared by paired t test; categorial data were compared by McNemar's test, respectively (Tables 1, 2, and 3). Differences were considered statistically significant if the p value was < 0.05. Additionally, the eight matching main criteria were tested for collinearity. Poisson distribution was employed to detect significant correlation among the eight matching criteria and number of postoperative complications, to estimate number of postoperative complications within a distinct postoperative period, and for pairwise comparison of postoperative risks within each particular matching criteria. All achieved results were tested for sensitivity by the model of negative binominal distribution.

Results

There were no statistically significant differences between study groups 1 and 2 regarding the pre- and perioperative characteristics. Thus, the performed matching by criteria mentioned above produced statistically comparable distinct groups (Tables 1 and 2).

The mean hospital stay was significantly longer in patients with SIS mesh repair (SIS mesh 22.0 ± 6.3 days vs. PP meshes 12.0 ± 3.1 days; p = 0,010; difference between means 10.21; 95% CI 6.29–13.13). The follow-up times were not significantly different in both groups (23.5 ± 3.7 months vs. 27.3 ± 4.3 months, p = 0.098; difference between means − 3.82; 95% CI − 15.90–6.33). However, there were significantly more surgical site occurrences (19 vs. 12, p = 0.041, Table 3) in group 1, but if these complications were divided up in hematoma, seroma, and soft tissue necrosis only the differences in hematoma and soft tissue necrosis were statistically significant. In addition, significantly more recurrent hernias were observed in group 1 (6/24 vs. 3/24, p = 0.004, Table 3).

In group 1, we observed seroma in 7 patients (29.2%), hematoma in 6 patients (25.0%), wound infections in 6

Table 2 Perioperative data for biologic versus alloplastic meshes

	Biologic (n = 24)	Alloplastic (n = 24)	Significance
Operative time	261.5 ± 92.4 95% CI 208.0–326.1	224.5 ± 73.7 95% CI 166.3–318.6	n.s., p = 0.067 (difference between means 37.1; 95% CI − 2.88–80.05)
CDC wound class			
Clean CDC I	2	2	N/A (matched pairs)
Clean-contaminated CDC II	12	12	
Contaminated CDC III	10	10	
Source of contamination			
Gastrointestinal	13	13	N/A (matched pairs)
Genitourinary	2	2	
Necrotising pancreatitis	3	3	
Immunosuppressants after liver transplantation	4	4	
None	2	2	
Hernia			
Defect width (cm)	9.0 ± 5.3	8.8 ± 6.0	n. s., p = 0.903
Defect length (cm)	14.3 ± 8.0	15.5 ± 7,6	n. s., p = 0.597
Defect area (cm^2)	154.8 ± 57.6, 95% CI 93.8–244.5	163.8 ± 73.0, 95%-CI 66.9–300.0	n. s., p = 0.753 (difference between means − 9.06; 95% CI − 47.74–35.00)
Hernia repair technique			
Retromuscular/sublay	14	14	N/A (matched pairs)
Onlay	6	6	
Underlay/IPOM	4	4	
Component separation	4	4	
Mesh characteristics			
Mesh size (cm^2)	433.8 ± 102.8 95% CI 384.3–491.4	408.3 ± 114.0 95% CI 277.9–527.7	n. s., p = 0.623 (difference between means − 25.56; 95% CI − 195.06–121.35)
Mesh type			
Porcine derived	24	–	
Polypropylene based	–	24	

patients (25.0%), and recurrent hernia in 6 patients (25%). But only two of these six patients with recurrent hernia had an SSO or SSI. None of the implanted SIS meshes, however, were explanted during the investigated postoperative course. In group 2, we observed seroma in 5 patients (20.8%), hematoma in 4 patients (16.7%), wound infections in 5 patients (20.8%), and recurrent hernia in 3 patients, where 2 patients had undergone an early mesh explantation due to wound infection CDC class III (12.5%). The mesh explantations were considered as recurrent hernias. The differences between both groups were statistically significant regarding the postoperative surgical site occurrences (p = 0.041) and the incisional hernia recurrences (p = 0.004). However, there was no significant difference in postoperative surgical site infections (p = 0.860, Table 3).

The eight matching main criteria, age, gender, profile of comorbidities, body mass index, hernia classification, mesh implantation technique, CDC wound class [15] and source of potential contamination/primary surgery performed, did not show evidence for collinearity. Therefore, these eight criteria are independent from each other. The Poisson's distribution unveiled a significant correlation between the number of perioperative complications and employed mesh material (p < 0.001), the body mass index < 18.5 (p = 0.003), and the hernia classification (p = 0.026; Table 4).

In the Poisson's distribution test, we estimated the probable distribution of postoperative complications after hernia repair within a distinct period. Biological mesh repair was estimated to be followed by 3–6 complications per month whereas alloplastic mesh repair was followed by 1–2 complications per month. Independently of the employed mesh material, male patients showed 1–2 complications per month; however, female patients showed 2–3 complications per month. There were no complications in underweighted patients. Median hernias were followed by 1–3 complications per month, lateral hernia by 1 complication point per month, and combined hernias by 1–2 complications per month. The commonly used sublay-implantation technique showed as well as the IPOM technique 1–2 complication points per month, the onlay-technique 1–4 complication points per month (Table 5). In the pairwise comparison, there was still a statistically significant difference between study groups 1 and 2 (p < 0.01). Female patients had one more complication per month than their male counterparts (p = 0.016). However, no significant differences could be found for the body mass index (p = 0.842), SSI, CDC wound class, profile of comorbidities, and in first incisional or recurrent incisional hernias (p = 0.312). Median hernias were combined with one more complication per month than lateral or combined hernias (p = 0.004 and p = 0.026). Lateral and combined hernias did

Table 3 Postoperative data for biologic versus alloplastic meshes

	Biologic (n = 24)	Alloplastic (n = 24)	Significance
Wound complications			
SSO	19	12	*s., p = 0.041*
Seroma	7	5	n.s., p = 0.052
Hematoma	6	4	*s., p = 0.035*
Soft tissue necrosis	6	3	*s., p = 0.006*
SSI			
Superficial	3	2	n.s., p = 0.860
Deep	3	3	
Intraperitoneal	0	0	
Postoperative results			
Mesh explantation	0	2*	
Hernia recurrence	6 (25.0%)	3 (12.5%)	*s., p = 0.004*
Follow-up (months)	23.5 ± 3.7, 95% CI 14.5–30.9	27.3 ± 4.3, 95% CI 18.1–34.5	n.s., p = 0.098 (difference between means − 3,82; 95% CI − 15.90–6.33)
Duration of hospital stay (days)	22.0 ± 6.3, 95% CI 15.8–23.4	12.0 ± 3.1, 95% CI 10.8–17.0	*s., p = 0.010* (difference between means 10.21; 95% CI 6.29–13.13)

*Mesh explantation was included in the number of hernia recurrence; italics mark significant p-values

not significantly differ from each other (p = 0.723). All mesh implantation techniques did not significantly differ from each other regarding the estimated postoperative complications. There were significant differences in postoperative seromas (group 1, 1.0 seroma per month vs. group 2, 0.1 seroma per month, p = 0.005) and postoperative recurrent hernia (group 1, 0.42 recurrent hernia per month; group 2, 0.14 recurrent hernia per month, p = 0.0341). There is a significant correlation (p < 0.001) between the number of expected complications and the employed mesh material. In the pairwise comparison, the biological mesh repair was followed by two- to threefold more complication points per month than the alloplastic mesh repair. The employed statistical models, both the Poisson's distribution and the negative binominal distribution, unveiled a statistically significant correlation (p < 0,001) between the calculated number of complication points per month and the employed mesh material in ventral incisional hernia repair. The SIS mesh repair was associated with averagely 3–6 estimated complication points, and the PP mesh repair with averagely 1–2 estimated complication points per month. In the pairwise comparison, we also found a significantly higher complication rate in study group 1 (p = 0.003).

Table 4 Statistical correlation with number of postoperative complications

Matching criteria	p values
Mesh material	< 0.001***
Gender	0.06
Age	0.632
Obesity	0.840
Underweight	0.003**
Hernia classification	0.0266*
Mesh implantation technique	0.1378
CDC classification [9]	0.098

* p < 0.05

** p < 0.01

*** p < 0.001

Discussion

Incisional hernia is the most frequent complication after laparotomy. [17] Although the alloplastic mesh hernia repair provides very good results [18], their use is not advisable in contaminated or infected operative sites in general. [3, 4] Aiming a significantly reduced risk of postoperative complications and extended indications, biological meshes were developed from human and animal tissues. [4] The feasibility and success of biological mesh repair have been shown by animal experimental and application studies. There have also been few trials comparing the approved alloplastic mesh repair with biological mesh repair or distinct biological mesh repair with each other in incisional hernias. [3, 8, 19, 20]

This presented study compares our results of SIS mesh repair (n = 24) with PP mesh repair (n = 24) in inicisional ventral hernias by matched-pair design. Both of our analyzed study groups did not show significant differences in their pre- and perioperative risk profiles, class of contamination, and hernia classifications. Patients with SIS mesh repair showed significantly more recurrent hernias (25 vs. 12.5%, p = 0.004), significantly more surgical site occurrences (mainly

Table 5 Estimated numbers of complications per month (Poisson's distribution)

	Estimated value for real number of complications	95% confidence interval	
Mesh material			
Biological	4.63	2.88	6.39
Alloplastic	1.53	0.91	2.26
Gender			
Male	1.13	0.75	1.70
Female	2.38	1.48	3.28
BMI			
Obesity (BMI > 30 kg/m^2)	1.59	0.78	2.40
Underweight (BMI < 18.5 kg/m^2)	0.18	0.09	0.24
Hernia classification			
Median	2.13	1.38	2.88
Transversal	0.63	0.11	1.14
Median and transversal	0.79	0.04	1.55
Mesh implantation technique			
Onlay	2.59	1.12	4.07
Sublay	1.17	0.55	1.78
IPOM	1.25	0.49	2.00

hematomas and soft tissue necrosis, $p = 0.041$), and stayed significantly longer in hospital (22.0 ± 6.3 vs. 12.0 ± 3.1 Tage, $p = 0.010$) compared to patients with PP mesh repair.

These results are to be considered with caution, since there are limitations of this study. Within the limits of retrospective studies with possible selection bias by a single study center, small patients numbers, heterogeneous cases of primary surgery leading to incisional hernias, choice of mesh material by surgeon's discretion, and partially incomplete data acquisition the confounders that are difficult to measure should be reduced by forming case-matched pairs. Matching allows to use a smaller sample size and matching on factors helps to balance their confounding role. However, matching on eight factors may lead to difficulties in recruiting appropriate controls. Only 187 of 352 patients (53.1%) could be considered for matching mainly because of incomplete data acquisition in 122 patients (34.6%) potentially excluding controls with different courses which could have influenced the statistical results. That is an important selection bias. Twenty-four of these 187 patients after PP mesh repair could be matched with 24 patients after SIS mesh repair. For example, to gain sufficient statistical power of 80% in a prospective randomized clinical trial with the same aims, the sample size should be 44 patients in each group for SSO and 168 patients in each group for recurrent hernia to validate our findings for these factors. Additionally, the risk factors associated with the matching variables cannot be examined, and if controls are not identified then the data collected from the cases cannot be used and vice versa. There is also the danger of a possible overmatching.

One further selection bias might be the present practice to implant biological meshes in patients with surgical site infections not allowing the employment of alloplastic meshes. Therefore, patients with biological mesh repair might be in a slightly worse stage. However, Cheesborough et al. showed in a prospective trial that contaminated and clean-contaminated abdominal wall defects could also be effectively treated with alloplastic meshes. [21] This finding has been confirmed by Majumder et al. most recently. [22] This confounder was reduced by forming matched pairs also regarding the degree of contamination according to the CDC wound classification, the source of contamination, and primary surgery leading to incisional hernias, respectively. Both of our analyzed study groups did not show significant differences in their classes of contamination. There is obviously no advantage in implanting SIS meshes compared to PP mesh hernia repair in clean, clean-contaminated, and contaminated incisional hernias in our patients. The selection of mesh material was to the surgeon's discretion, hematomas and soft tissue necrosis are not directly related to employed mesh material, and the SIS meshes had been the first biological meshes we implanted in our patients with incisional hernia. Therefore, we had limited experiences with this kind of meshes and had had an undeniable learning curve. Nevertheless, during the observation period, only few hernia centers could report about extended experiences with biological meshes. [8, 12] Our results can only be related to porcine intestinal submucosa-derived non-cross-linked meshes and to polypropylene-based alloplastic meshes. Mesh materials based on porcine intestinal submucosa have been licensed for the repair of tissue defects since

1999. [4] Surgisis® mesh is the most employed representative in surgical hernia repair examined in several trials. [23] Franklin et al. reported promising results if these meshes were implanted in potentially or definitively contaminated operation situs: no mesh-related complications nor recurrent hernias in 25 patients within a follow-up of 15 months [24], and rare complications such as wound seroma and 5.3% recurrent hernias in 133 patients after 5 years. [25] Bellows et al. performed 135 incisional hernia repairs employing porcine intestinal submucosa and found recurrent hernia in only 7.4%. [3] According to Hiles et al., the use of porcine intestinal submucosa-based biological meshes is feasible in hernia surgery with an average failure rate of 6.7% within 19 postoperative months. [26] However, Smart et al. found that Surgisis® meshes should only by employed in non-contaminated areas since the rate of recurrent hernia increases up to 39% if these meshes were used in contaminated areas. [27] Therefore, Cocollini et al. recommended the use of non-cross-linked meshes such as SIS meshes in potentially contaminated and smaller hernias and cross-linked meshes in infected and bigger hernias. [23] Although we implanted the non-cross-linked biological mesh in accordance to recommendations, we could not achieve similar good results (25% recurrent hernias after SIS mesh repair, 12.5% recurrent hernias after PP mesh repair). However, none of the SIS meshes had to be explanted, whereas two of alloplastic meshes had to be explanted due to severe infection in our patients. Most recently, Majumder et al. also reported 26.3% recurrent hernias after biological (non-cross-linked porcine acellular dermal xenografts) hernia repair vs. 8.9% recurrent hernias after alloplastic hernia repair in a multicenter retrospective review of 126 patients with CDC classes II and III ventral hernias and a mean follow-up of 20 months. [22] They explained the higher recurrence rate after biological mesh repair in CDC classes II and III ventral hernias by the inability of the biologic mesh to integrate and to resist bacterial degradation, thus leading to mesh breakdown and recurrence. Helton et al. and Edelman and Bellows reported recurrence rates of 16 and 6.25%, respectively, within 14 postoperative months after SIS mesh repair. [13]. The published results of SIS mesh repair in incisional hernias are heterogeneous, suggesting biological meshes of dermal origin perform better than meshes of submucosal origin. [8, 10] Our results are supported by experimental data of Ditzel et al. [28] and clinical data of Coccolini et al. [29] and Fischer et al. [30] Gruber-Blum et al. experimentally proved a reduced tissue integration and significant shrinkage in porcine and bovine meshes in comparison to biosynthetic meshes, prohibiting further biomechanical tests. [31] Primus and Harris found in a systematic review that the use of biological meshes for incisional hernia repair under contaminated conditions is not better than synthetic meshes within the same conditions. [32] However, the current evidence suggests that biologic grafts perform similarly to other surgical options. [33]

A prospective comparative trial of autodermal graft versus PP meshes for large incisional hernia repair enrolling 40 patients within a 10-year period was published by Stojiljkovic et al. They reported a recurrence rate of 10% in the autodermal group and 15% in the group with PP meshes. According to Smart et al. (2012), hernia repair with Permacol® meshes (cross-linked porcine acellular dermis) were associated with a lower failure rate than the repair with Alloderm® or Surgisis® (non-cross-linked) meshes, particularly in contaminated operative sites. [27] Obviously, the employed biological material with its distinct characteristics substantially influences the outcome of hernia repair with biological meshes.

Although we observed in total significantly more surgical site occurences and significantly more hematoma and soft tissue necrosis after SIS mesh hernia repair, there were in accordance with Franklin et al. [24, 25], Bellows et al. [3], and Hiles et al. [26], not significantly more postoperative seromas and wound infections in patients with SIS mesh repair compared to PP mesh repair within a follow-up period of at least 24 months.

Despite the limitations of this single-center retrospective matched-pair analysis in our study, all statistical tests give evidence that SIS mesh repair does not appear to be superior to the PP mesh repair in similar surgical indications, degree of wound contamination, and incisional hernia classifications. Since costs of SIS meshes are still much higher, that might also have socioeconomical implications. [34]

Conclusions

This retrospective matched-pair analysis could not prove a significantly better performance of SIS mesh repair compared to PP mesh repair in incisional hernias with different degrees of wound contamination. We found significantly more surgical site occurrences and hernia recurrences in the SIS mesh group. Further prospective and randomized trials or at least registry studies such as the EHS register with standardized and defined conditions are warranted to test distinct biological meshes (acelluar dermis, intestinal submucosa, human, animal, cross-linked versus non-cross-linked) in comparison with the more cost-effective and approved alloplastic mesh repair in ventral incisional hernia repair.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval All procedures performed in this study involving human participants were in accordance with the ethical standards of the institutional and national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent Informed consent was obtained from all individual participants included in the study.

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