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ARTICLE

Reinforcement of the abdominal wall with acellular dermal matrix or synthetic mesh after breast reconstruction with the pedicled transverse rectus abdominis musculocutaneous flap. A prospective double-blind randomized study

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ABSTRACT

Introduction: The pedicled transverse rectus abdominis musculocutaneous flap (p-TRAM) is a well-established option for autologous breast reconstruction (BR) but donor-site morbidity is still reported. The aim of the present study was to compare donor-site morbidity after reinforcement of the abdominal wall regarding development of bulging or hernia, abdominal muscle strength, complications, and abdominal pain hypothesizing, that reinforcement with acellular dermal matrix (Strattice™) is superior to reinforcement with synthetic mesh (Prolene®).

Materials and methods: A randomized, prospective, double-blind study was conducted with 29 patients admitted for BR with the p-TRAM flap at Department of Plastic Surgery, AUH, Denmark, 2014–2016. Allocation rate 1:1. Follow-up at 4, 12, and 24 months.

Results: 24 months postoperatively the computerized tomography verified bulging frequency was 35.7% in the ADM group and 6.7% in the synthetic mesh group ($p = 0.11$). Two patients (14.3%) in the ADM group and no patients in the synthetic mesh group developed hernia. No significant difference between baseline and 2-year measurement of abdominal muscle strength was observed.

Conclusion: The present study did not demonstrate any statistically significant differences between treatment groups regarding risk of bulging or hernia, abdominal muscle strength, complications, pain or pain related QoL within two years of follow-up. Although the small sample size sets limitations for drawing wide conclusions the hypothesis that reinforcement with ADM is superior to synthetic mesh cannot be confirmed. Further research into methods for decreasing donor-side morbidity related to the TRAM flap or other rectus abdominis muscle-based flaps is needed.

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Breast reconstruction; complication; pedicled TRAM flap; rectus abdominis muscle-based flap; donor-site morbidity; ADM; synthetic mesh

Introduction

The transverse rectus abdominis musculocutaneous (TRAM) flap is an important option for autologous breast reconstruction (BR) [1] and other reconstructions such as coverage of inguinal defects [2] and reconstruction of the chest wall after re-recurrent breast cancer [3]. The free TRAM flap was first described by Holmström in 1979 [4] and later introduced by Hartrampf et al. as a pedicled flap [5]. Even though the flap is widely used, also with other skin islands, it may be associated with donor-site morbidity as abdominal bulge or hernia [6] and feeling of abdominal tightness [7]. The abdominal weakness has been sought diminished by using different techniques such as direct suture of the remaining rectus fascia, using the adjacent fascial layers or reinforcement with synthetic mesh or dermal transplants [8]. Synthetic mesh has been used for many years to reinforce the abdominal donor-site [9]. However, there is a risk of infection and of development of foreign body reaction and chronic inflammation which may result in contracture and chronic pain [10]. The introduction of biological meshes gave the possibility of an alternative reinforcement material to obtain a dynamic abdominal wall reconstruction and decrease donor-site morbidity. In a meta-analysis from 2011 Adetayo et al. found a frequency of bulging and herniation on more than 25% when using Alloderm for reinforcement of the abdominal wall [11]. However, in 2012, Cicilioni et al. observed no bulging or herniation after reinforcement of the abdominal donor-site with the porcine non-crosslinked ADM Strattice™ [12]. Reconstructing the fascial defect with porcine ADM may be promising and there is a lack of studies directly comparing abdominal wall reinforcement with either synthetic mesh or ADM.

Hypothesizing that reinforcement with ADM results in less bulging at the abdominal donor-site and less abdominal discomfort compared to reinforcement with synthetic mesh the present randomized study was initiated. The aim was to compare donor-site morbidity after reinforcement of the abdominal wall with either synthetic mesh (Prolene®) or porcine non-crosslinked ADM (Strattice™) after breast reconstruction using the pedicled TRAM flap with regard to development of bulging or hernia, abdominal wall function, postoperative complications and abdominal pain.

Materials and methods

Study design and participants

The present study is a single-center, double-blind (patient and investigator), prospective, randomized controlled trial with two

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Supplemental data for this article can be accessed on the here.

groups, allocation ratio 1:1. All patients undergoing autologous BR with the pedicled TRAM flap at Aarhus University Hospital, Denmark during the inclusion period (January 2014–November 2016) were offered inclusion in the study. Exclusion criteria were age less than 18 years, smoking less than 4 weeks prior to surgery and patients not able to understand enough Danish to comprehend the given information and to complete the study questionnaire. Data were obtained from patient records and participants underwent clinical examination, performed by the investigator, before surgery and at follow-up visits at four, 12 and 24 months. All performed by the investigator. Thus, follow-up time was 24 months.

Surgical techniques

Randomization was performed perioperatively and patients were allocated to reinforcement of the abdominal donor-site with either synthetic mesh (Prolene®) or ADM (Strattice™ Firm). The inlay technique described by Cicilioni et al. [12] was used. The reinforcement material was trimmed and contoured to the width and length of the rectus muscle harvested and positioned between the anterior and posterior layers of the rectus fascia (Figure 1(A)). The caudal edge of the reinforcement material was fixed to Cooper's ligament with interrupted 0 nonabsorbable suture. The cranial edge of the material was sutured to the posterior layer of the rectus sheath, just below the costal margin. Horizontal mattress sutures of 0 non-absorbable suture was used to fix the reinforcement material to the medial and lateral cuff of the posterior layer of the rectus sheath. A running 1 non-absorbable suture was used to close the anterior layer of the rectus sheath primarily above the umbilicus. Below the umbilicus, the anterior layer of the rectus sheath was pulled as medially as possible. Two suction drains were placed and the abdominal was closed with progressive tension sutures.

Outcomes

Primary endpoint was bulge or hernia at the abdominal donor-site diagnosed by computerized tomography (CT) scan at 24 month follow-up. Patient and investigator assessment of bulging or hernia was also reported. Bulge was defined as a visible protrusion of the abdominal wall, without a defect in the abdominal fascia. Hernia as a protrusion of the abdominal wall with a defect in the abdominal fascia. Patient assessment was obtained in a study-specific questionnaire concerning the entire abdominal wall and not specified in donor-side (mesh side) and contralateral side (no-mesh side) (Q: Have you noticed abdominal bulge or signs of hernia? Y/N).

Investigator assessment was performed with inspection and palpation of the abdominal wall under Valsalva's maneuver at clinical follow-up visits. An abdominal CT scan was performed under Valsalva's maneuver 12 and 24 months postoperatively. Bulge was defined as a protrusion of the abdominal wall without a defect in the abdominal fascia. Hernia was defined as a protrusion of the abdominal wall with a defect in the abdominal fascia. One radiologist, blinded to the randomization, reviewed all CT scans.

The secondary outcomes were abdominal muscle strength, complications and pain as described. Abdominal muscle strength was measured with fixated hand-held dynamometer before surgery and at 12 and 24 month follow-up. All measurements were performed by investigator in the same standardized way using The PowerTrack II™ (JTech Medical Industries, Salt Lake City, UT) (see Figure, Supplemental Digital Content 1, which illustrates the setup for measuring abdominal muscle strength using the fixed hand-held dynamometer). The patient was placed in a supine position with legs straight and the arms along the body. The dynamometer was placed in a tripod, adjustable with belts, and placed below the xiphoid process. After instruction the patient performed a trial run to familiarize with the dynamometer. The patient was strongly encouraged to perform maximal effort at each trial in a standardized manner. A resting period at 30 s was allowed between each test and the test was repeated until peak

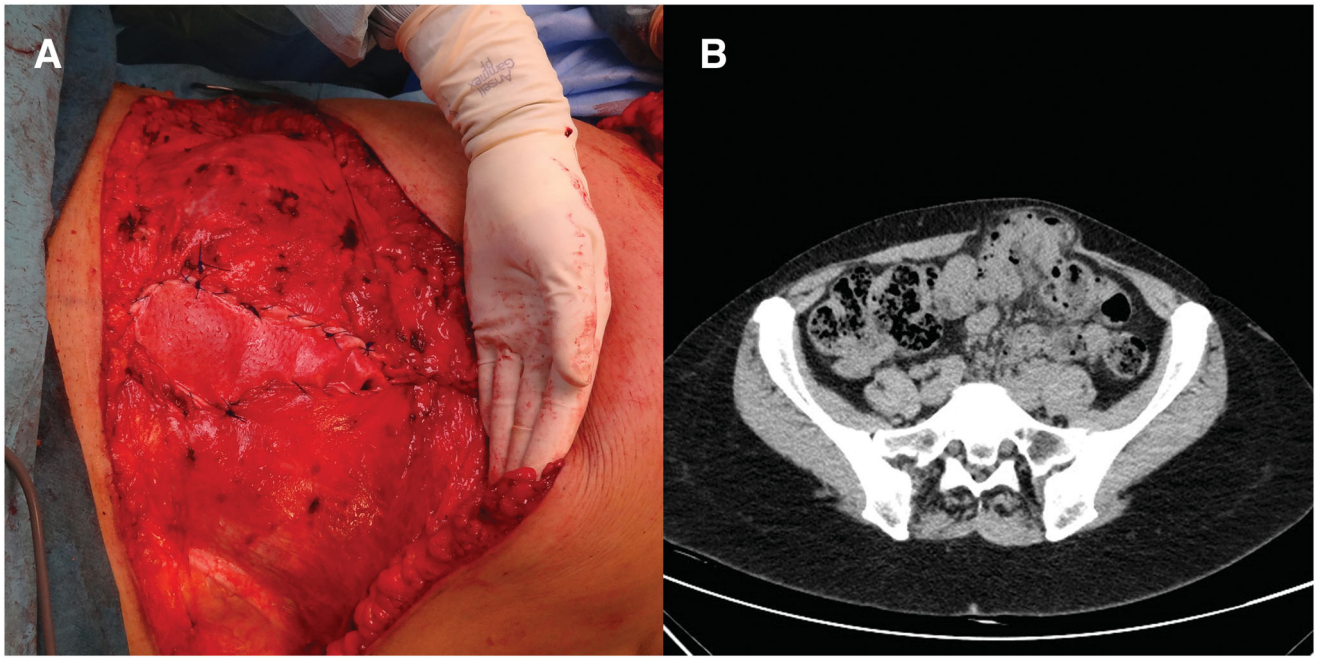

Figure 1. Illustration of ADM reinforcement and hernia. (A) Reinforcement of the abdominal donor-site with ADM (Strattice™). (B) CT scan illustrating donor-site hernia after reinforcement with ADM.

was clearly reached and the maximum score was chosen. Immediately after the last test the patient was asked to assess pain during the exercise on a Visual Analogue Scale (VAS) instrument.

Donor-site complications were pooled in major and minor complications. Major complications included hematoma requiring surgical intervention, infection requiring surgery, and skin necrosis requiring revision. Minor complications included cellulitis/wound infection requiring treatment with antibiotics and seroma requiring intervention. All complications were identified through review of patient records at 4-month follow-up visit.

Information regarding preoperative abdominal pain or discomfort were obtained from the patient by investigator at the preoperative clinical examination (Q: Do you feel pain or discomfort located to the abdomen? Y/N). The patients fulfilled a study-specific questionnaire at follow-up visits consisting of the following four questions: Have you, within the last month, had a feeling of tightness located to the abdomen? (Y/N). Have you, within the last month, had a cutting/stabbing/shooting sensation located to the abdomen? (Y/N). Furthermore, patients completed the Dolotest ® (EvidenceProfile ApS, Denmark) regarding abdominal pain at each follow-up visit. Dolotest® is a validated instrument measuring pain intensity and health related quality of life (QoL) in pain patients in average over the past week [13]. The instrument consists of eight domains each evaluated on a VAS scale with 0 representing no problems and 100 representing worst possible problems (to what extent do you experience pain; problems with light physical activity; problems with more strenuous physical activity; problems doing your job; reduced energy and strength; low spirit; reduced social life; and problems sleeping) (see figure, Supplemental Digital Content 2, which illustrates Dolotest®). Patients were instructed according to the developers' recommendation. A total score was calculated by summating the eight scores (range 0–800) with higher scores representing worse pain related QoL.

Sample size

Sample size calculation was based on bulging as endpoint. The minimum relevant difference the study was aiming for was a 6% points absolute reduction in bulging frequency between the synthetic mesh and the ADM group. Power was set to 80%. Bulging frequency was estimated by following studies to 7% [14] and 10% [7] for reinforcement with synthetic mesh and 0% [12] for reinforcement with ADM. It was planned to include 20 patients in each treatment arm but inclusion was terminated 16th November 2016 to be able to achieve two years of follow-up within the duration of the project.

Randomization

Patients were randomized using a permuted block design with blocks of 4 and 6 according to the SNOSE principles [15] and a researcher without involvement in the study prepared the allocation sequence. Investigator enrolled patients and an instructed nurse performed the randomization perioperatively.

Blinding

The plastic surgeon wrote a standard text for the patient record without revealing what material was used for reinforcement of the abdominal donor-site. The randomization was revealed if complication occurred that could be related to the use of reinforcement material and after 2 years of follow-up. The investigator did not participate during the breast reconstruction procedure and, thus, the patient, care providers, radiologist, and investigator were blinded for the intervention.

Statistical analysis

Descriptive statistics were used for patients' demographics stating mean and standard deviation for continuous variables. Categorical variables were compared between study arms using Fisher's exact test while continuous variables were compared by a *t*-test. Binary outcomes were analyzed using generalized linear model with log link function and repeated observations were taken into account. Continuous outcomes were analyzed using mixed model for repeated measurements by including patient id as random effect. Due to the small sample size, the Kenward Roger approximation method was used to calculate the degrees of freedom. Follow-up time and the group (ADM or synthetic mesh) variables were used as fixed effects in the model, and the interaction of them. Risk or risk ratios for the dichotomous outcome and mean or mean difference for the continuous outcome were presented with 95% confidence interval and *p*-values. Dolotest® score were scaled up to eight questions for the two patients who answered only seven questions by multiplying their mean score by eight. Two sensitivity analysis were performed. One without the patient who had very high value at 4 months follow-up and influencing the model result and another sensitivity analysis without the two patients who answered only seven questions. Abdominal strength measurements were adjusted for VAS score. The significance level was set to 0.05. Statistical analyses were performed using STATA® software IC16 (Stata Corporation, College Station, TX).

Ethical considerations and registrations

This study was conducted in accordance with the Declaration of Helsinki and all participants gave written informed consent. The Ethics Committee of the Central Region of Denmark (1-10-72-10-13) and The Danish Data Protection Agency (1-16-02-7-13) approved this study and it was submitted in ClinicalTrials.gov (NCT02076724). Study data were collected and managed using REDCap electronic data capture tools hosted at Department of Clinical Medicine, Aarhus University. This study followed Consolidated Standards of Reporting Trials (CONSORT) guidelines.

Results

A total of 29 patients were included in the study. After randomization 14 patients were assigned to reinforcement of the abdominal donor-site with ADM and 15 patients to reinforcement with synthetic mesh. No patients were lost to follow-up (Figure 2). The two treatment groups did not differ significantly regarding demographics and clinical characteristics as summarized in Table 1.

The patients observed an increasing tendency of abdominal wall weakness from 4 to 24 months follow-up where more than 50% in both treatment arms experienced abdominal bulge or hernia (Table 2).

Investigator observed no bulging at the donor-side at four months follow-up, but a higher risk in the ADM group (51.7%) compared to the synthetic mesh group (20%) at 24 months follow-up, although this was not significant (RR 2.9, $p = 0.068$). CT scan confirmed bulging at the donor-side in 35.7% of patients in the ADM group, but only in 6.7% of the synthetic mesh group (RR 5.4, $p = 0.109$). The investigator also observed a 21–28% risk

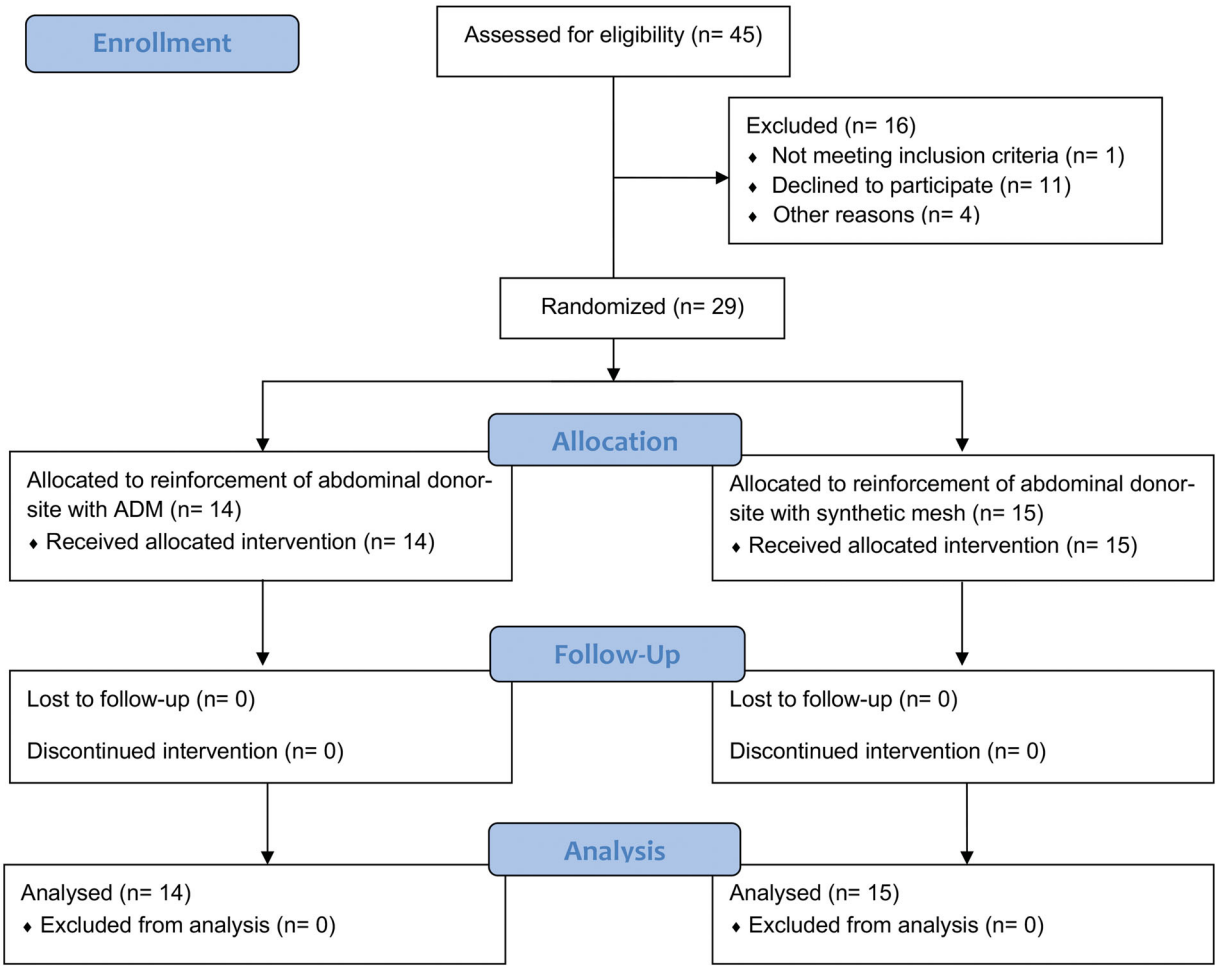

Figure 2. Consolidated Standards of Reporting Trials (CONSORT) 2010 flow diagram.

Table 1. Demographics and clinical characteristics.

	ADM Patients $n = 14$	Synthetic mesh Patients $n = 15$
Age, years, mean (SD)	51.9 (8.7)	51.6 (9.9)
BMI, kg/m^{2,} mean (SD)	26.2 (2.9)	26.4 (3)
Comorbidity[a]	5	6
Timing of breast reconstruction		
Immediate	1	0
Delayed	13	15
Anti-estrogen treatment	7	10
Pain in abdominal wall prior to surgery	2	0
Former abdominal surgery	7	10
Hospitalization, days, mean (SD)	10 (4)	9.2 (2.8)
Sick leave, days, mean (SD)[b]	66.6 (32.3)	53.7 (34.3)

BMI indicates body mass index.
[a]Missing value for 1 patient in the synthetic mesh group.
[b]Missing value for 4 patients in the ADM group and 5 patients in the synthetic mesh group.

of bulging at the contralateral side (no-mesh side) in both groups. This phenomenon was already present at four month follow-up and did not change through the study period. The investigator observed hernia at the donor-side in two patients (14%) in the ADM group at 12 month follow-up and this finding was confirmed by CT scan at 12 and 24 month follow-up (Figure 1(B)). Only one patient in the synthetic mesh group was found to have a hernia at the mesh side at 24 month follow-up, but this was not confirmed by CT.

There was no significant difference in the mean dynamometer test score between the groups at any time point ($p = 0.69$) and no significant difference between baseline score and 24 month score within any of the two treatment groups (ADM difference −12.2, 95% CI −25.8 to 1.4, $p = 0.077$; synthetic mesh difference −4.5, 95% CI −18.6 to 9.7, $p = 0.519$). The ADM group had a higher preoperative mean abdominal muscle strength (53.3 N, 95% CI 39.2–67.5) compared to the synthetic mesh group (47.3 N, 95% CI 33–61.7), but a lower test score at 24 month follow-up (ADM: 40.9 N, 95% CI 27.1–54.7; synthetic mesh 42.8 N, 95% CI (29.5–56.1) (Figure 3). Adjusting for VAS score did not change the conclusions.

There was no significant difference between groups regarding postoperative complications at the abdominal donor-site. Major complications, resulting in surgery, were distributed as follows: one patient in the ADM group had an infection, two patients in the synthetic mesh group experienced necrosis. No patients in the synthetic mesh group suffered from minor complications, whereas two patients in the ADM group had seroma and cellulitis, respectively.

Feeling of abdominal tightness decreased from four to 24 month follow-up. In the ADM group from 77% (CI 57–104%) to 43% (CI 23–79%), and in the synthetic mesh group from 75% (CI 54–105%) to 60% (CI 39–91%), respectively. At 24 month follow-up there was not statistically significant difference between groups (RR 0.7, $p = 0.376$). Feeling of cutting/stabbing/shooting sensations also decreased from four to 24 month follow-up. At 4-month follow-up 67% (CI 44–100%) of the patients in the ADM reinforcement group reported cutting/stabbing/shooting sensations which decreased to 43% (CI 23–79%) at 24 month follow-up.

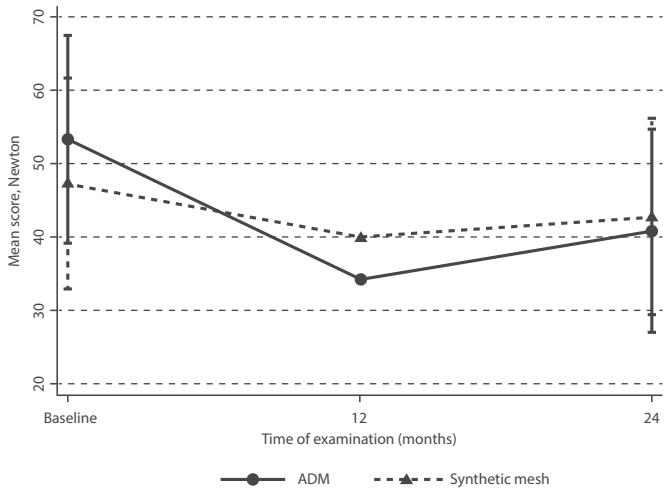

Figure 3. Abdominal muscle strength adjusted for VAS score.

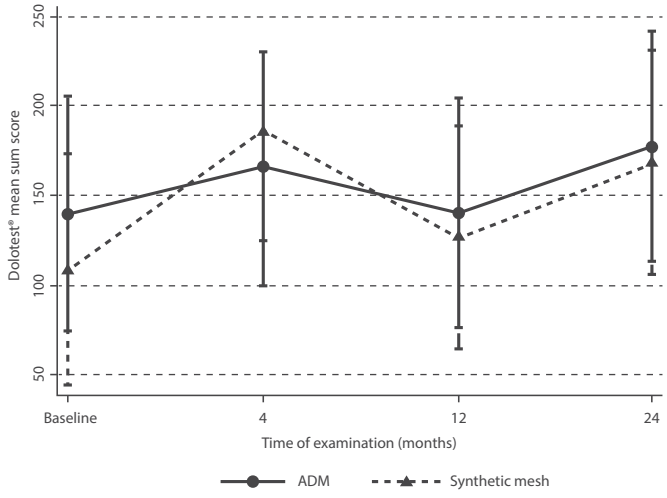

Figure 4. Pain-related quality of life. Dolotest ® score range 0–800. Higher scores representing worse pain related QoL.

Similarly, in the synthetic mesh group, 82% (CI 62–109%) of the patients reported cutting/stabbing/shooting sensations at four month follow-up compared to 53% (CI 33–86%) at 24 month follow-up. The difference between groups at 24 month follow-up was not statistical significance (RR 0.8, $p = 0.583$).

There was no significant difference in pain related QoL between the treatment groups at any of the time points ($p = 0.65$) (Figure 4). The synthetic mesh group demonstrated a significant decrease in pain related QoL over time (increasing Dolotest® score) as baseline Dolotest® score was 59 points less (95% CI: −117 to 2, $p = 0.044$) than 24 month follow-up score. In the ADM group, a difference at 38 points less at baseline (95% CI −96 to 20, $p = 0.197$) was observed. The two sensitivity analyses did not change the conclusions.

Discussion

The purpose of the present study was to evaluate abdominal weakness in its broadest sense, applying patient- as well as investigator assessment and in addition CT of the abdominal wall. The investigator and CT did not always align in the diagnosis of bulging and herniation and one could argue, that the opinion of the patients is of most importance. Twenty-four months after BR more than 50% of patients observed abdominal bulging. The patients did not distinguish whether the bulge was located at the donor side or the contralateral side. At the contralateral side an equally high frequency of bulging (21–28%) was observed in the two treatment groups, leading to the conclusion, that the reinforcement material might in some cases have been tightened too much perioperatively, resulting in paradox bulging of the contralateral side of the abdominal wall. This phenomenon has, to our knowledge, not been described by others. Both investigator and CT scan observed a higher frequency of bulging at the donor side at 24-month follow-up in the ADM group compared to the synthetic mesh group although this tendency was not significant (investigator $p = 0.068$; CT scan $p = 0.109$). CT diagnosed hernia was only observed in the ADM group (14%). One other study has used the same ADM product and found no development of bulge or hernia within a 10–20 months period after surgery. The diagnose of bulge or hernia was in this study based upon clinical finding in a standing position without Valsalva's maneuver. No CT was performed to verify the clinical finding [12]. The rate of CT verified bulging and hernia in the synthetic mesh group of this study after 24 month follow-up (bulging 6.7%; hernia 0%) is in accordance with previously published data from our institution after reinforcement with synthetic mesh (bulging 10%; hernia 0%) [7] and comparable with hernia and bulge risk found by others after reinforcement with synthetic mesh [16,17].

Multiple factors play a role in the risk of development of hernia or abdominal weakness after TRAM flap surgery including obesity [18], prior lower abdominal surgery with midline incision [19] and chemotherapy [20]. None of the patients in this study had a BMI $> 30\,kg/m^2$, received adjuvant chemotherapy or had undergone abdominal surgery with midline incision. Recently Huber et al. investigated the association between anti-estrogen treatment and development of bulge or hernia. They found increased odds ratio for development of hernia (OR 1.5, 95% CI 0.698–3.311) for patients treated with anti-estrogen therapy compared with patients not treated with anti-estrogen medication [16]. The present study could not verify this. Patients not receiving anti-estrogen treatment had a 42% higher risk of developing bulge or hernia at the abdominal donor-site than the patients treated with anti-estrogen medicine at 24-month follow-up (RR 1.42; 95% CI 0.43–4.67, $p = 0.57$).

Other biological materials have been studied in an attempt to find a substitute for synthetic mesh. In 1998, a study was published using dermal autograft for reinforcement of the pedicled TRAM flap donor-site where a bulging rate at 8.6% and hernia rate at 4.2% was demonstrated [21]. Later Glasberg et al. used human acellular dermal matrix (Alloderm) for reinforcement and found a bulging rate at 16.7% with insertion under appropriate tension and no explantation of the biological mesh despite exposure [22]. In 2009, Boehmler et al. demonstrated a bulging rate at 20% with reinforcement with Alloderm inlay graft and primary closure but also concluded that synthetic mesh as an inlay graft had a lower bulging rate (5%) and that polypropylene mesh was preferable over human ADM when mesh was needed [14]. In a meta-analysis from 2011, Adetayo et al. found a bulging rate at 28.1% and hernia rate at 27.6% after reconstruction of the abdominal wall with Alloderm [11]. Others have used porcine ADM in a cross-linked variety for reinforcement of the abdominal donor-site after TRAM flap BR. Reinforcement with this material resulted in 50% incidence of local wound complications and more than 25% developed hernia. The authors hypothesized that the complications were due to limited tissue integration and chronic inflammation, a foreign body reaction in the subacute period that

Table 2. Abdominal bulge or hernia.

	ADM $n = 14$ (n) risk (95% CI)			Synthetic mesh $n = 15$ (n) risk (95% CI)				
	4 months	12 months	24 months	4 months	12 months	24 months	RR (95% CI)[a]	p
Patient assessed bulging/hernia	[2] 15.4% (4.2–56.3%)	[6] 46.2% (25.4–3.9%)	[9] 64.3% (43.2–95.6%)	[4] 36.4% (16.4–80.6%)	[5] 33.3% (16.1–69.1%)	[8] 53.3% (32.9–86.3%)	1.2 (0.6–2.3)	NS
Investigator observed bulge at donor-side	0	[5] 35.7% (17.5–73%)	[8] 57.1% (36–90.7%)	0	[4] 26.7% (11.4–62.6%)	[3] 20% (7.1–56%)	2.9 (0.9–8.8)	NS
Investigator observed bulge at contralateral side	[3] 21.4% (7.7–59.5%)	[1] 7.1% (1–48.9%)	[4] 28.6% (12.3–66.4%)	[3] 21.4% (7.7–59.5%)	[4] 26.7% (11.4–62.6%)	[4] 26.7% (11.4–62.6%)	1.1 (0.3–3.6)	NS
Investigator observed hernia at mesh side	0	[2] 14.3% (3.9–52.7%)	0	0	0	[1] 6.7% (1–45.8%)		
CT verified bulge at mesh side	N/a	[5] 35.7% (17.5–73%)	[5] 35.7% (17.5–73%)	N/a	[2] 13.3% (3.6–49.6%)	[1] 6.7% (1–45.8%)	5.4 (0.7–41.8)	NS
CT verified hernia at mesh side	N/a	[2] 14.3% (3.8–54.1%)	[2] 14.3% (3.8–54.1%)	N/a	0	0		

N/a: not available; NS: not significant.
[a]Comparison between groups at 24 months (synthetic mesh group as reference).

might be attributed to the preparation of these crosslinked collagen products [23]. It has previously been shown that non-cross-linked porcine ADM became infiltrated with host cells and vessels rather than being encapsulated by scar tissue, as occurred with cross-linked porcine ADM [24].

Abdominal wall function has been assessed by using different objective measurements including the ability to perform sit-ups [25] and by isometric dynamometer [26,27]. In this study, hand-held dynamometer fixed with a tripod was used to measure concentric activity (muscle contracting whilst simultaneously shortening). This method has previously been found reliable for the assessment of back extensor muscle strength [28]. Analysis were adjusted for VAS score as it was expected that patients would perform worse if the exercise induced pain. The present study did not demonstrate any statistically significant difference in mean concentric abdominal muscle strength between the treatment groups at any timepoint. Furthermore, no statistically significant difference between 24 month follow-up and baseline mean test score in any of the treatment groups was found. It was expected to see a decrease in abdominal muscle strength after transposition of one of the rectus muscles, and the result in this study is in accordance with Dulin et al. who found a decreased abdominal strength, but not significant, after 1 year in the pedicled TRAM flap group [27]. In contrast, Kind et al. demonstrated a significant impairment of isometric trunk flexion for the pedicled TRAM flap group at 1-year follow-up [26]. It was expected to see that the patient with time regains strength of the abdominal muscles or use adjacent muscles to compensate. This phenomenon has also been demonstrated by others [26].

The hypothesis that reinforcement using synthetic mesh leads to discomfort or pain due to the rigid properties of the material could not be verified. Even though patients in the ADM group experienced less abdominal tightness and less cutting/stabbing/shooting sensations this was not statistically significant ($p = 0.376$ and $p = 0.583$, respectively). Atisha et al. reported that 45–50% of patients reconstructed with the pedicled TRAM flap reported tightness in the abdomen with a mean follow-up time at 7.7 years after BR [29]. Compared to this, the result of this study do not stand out. In the present study no effect of reinforcement material on pain related QoL measured by Dolotest ® was demonstrated. But it was noted that the synthetic mesh group had a significantly higher score (decreasing pain related QoL) at 24 month follow-up compared to baseline. This should be taken with some precautions as this group had a lower baseline score compared to the ADM group.

The randomized and blinded study design is a strength for this study. Furthermore, only three experienced surgeons and one investigator was involved. Any detectable bulge or hernia was registered by the independent investigator (MEB) and in addition, objective evaluation of the endpoints (CT scan, dynamometer) was applied. This study is clearly limited by small sample size and consequently large confidence intervals making it difficult to draw statistically solid conclusions. A study specific questionnaire was used to assess pain as a Danish version of a validated questionnaire to assess postoperative outcome e.g. Breast-Q was not available.

Many plastic surgeons would aim for using the deep inferior epigastric perforator (DIEP) flap for autologous BR when possible, but the TRAM flap may be a valid alternative in selected patients and is still an important part of the plastic surgeon's armamentarium like other rectus abdominis muscle-based flaps for reconstruction of perineal, pelvic, thoracic, and head and neck defects.

Therefore, further randomized studies are necessary to identify techniques or materials to decrease the donor-site morbidity after reconstruction using rectus abdominis muscle-based flaps. In the present study hernia and bulge at the donor-site were diagnosed at 12 month follow-up and remained unchanged until 24 month follow-up leading to the conclusion, that for studies aiming to describe hernia and bulging frequency, 12 months follow-up time may be the minimum.

Conclusion

The present study did not demonstrate any statistically significant differences between treatment groups regarding risk of bulging or hernia, postoperative abdominal muscle strength, complications, pain or pain related QoL within 2 years of follow-up. Although the small sample size sets limitations for drawing wide conclusions the hypothesis that reinforcement with ADM is superior to reinforcement with synthetic mesh cannot be confirmed. Further research into methods for decreasing donor-side morbidity related to the TRAM flap or other rectus abdominis muscle-

based flaps is needed. Finally, bulging and herniation seems to develop within the first postoperative year and for future studies aiming to investigate this endpoint 12 months is suggested to be the minimum time of follow-up.

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Disclosure statement

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