Lower Abdominal Bulge After Deep Inferior Epigastric Perforator Flap (DIEP) Breast Reconstruction

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Abstract: The etiology of lower abdominal bulge following breast reconstruction with the DIEP flap is uncertain. Most studies report an incidence that ranges from 0.7% to 5%. The purpose of this study was to review a set of factors that may predispose to a lower abdominal bulge. This was a retrospective review of 123 women who had breast reconstruction with the DIEP flap over a 4-year period. The reconstruction was unilateral in 93 women and bilateral in 30 women, totaling 153 flaps. Etiologic factors that were evaluated included patient age, diabetes mellitus, tobacco use, previous abdominal operations, unilateral or bilateral reconstruction, previous childbirth, aponeurotic plication to improve the natural abdominal contour, and use of Marlex mesh. A lower abdominal bulge occurred in 5 of the 123 women (4%), 2 following 30 bilateral reconstructions (6.6%) and 3 following 93 unilateral reconstructions (3.2%). Analysis of the factors for all women demonstrated diabetes mellitus in 1 (0.8%), tobacco use in 9 (7.3%), a prior abdominal operation in 55 (44.7%), previous childbirth in 95 (77%), aponeurotic plication in 49 (40%), and use of Marlex mesh in 4 (3.3%). Statistical analysis did not show any significant association between the explanatory factors and the occurrence of a lower abdominal bulge, except for a weak trend in women who had not been pregnant ($P = 0.08$). The results of this study demonstrate that the occurrence of a lower abdominal bulge following the DIEP flap is a random event that can occur in anyone. Pregnancy may confer a preventative effect as the collagen fibers strengthen to overcome the stretching forces. Techniques for prevention and treatment include intraoperative assessment of the anterior rectus sheath, use of an adjuvant material for reinforcement if unstable, and vertical plication for bulge repair.

Key Words: abdominal bulge, DIEP flap, breast reconstruction

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The etiology of lower abdominal bulge following breast reconstruction using the DIEP flap is unclear. In most studies the incidence has ranged from 0.7% to 5%[1–3]; however, in a single study the incidence was 33%.[4] This is perplexing because the normal supportive and functional elements of the anterior abdominal wall are not removed with the DIEP flap. This is in contrast to the other methods of breast reconstruction using abdominal flaps in which the supportive and functional elements are removed to some degree.

Our understanding of lower abdominal bulge following breast reconstruction with abdominal flaps has improved over the years. The reported incidence following pedicle or free TRAM flaps ranges from 1% to 40%.[5–8] Techniques in which decreasing amounts of muscle are removed have demonstrated no predisposition or correlation to the development of an abdominal bulge.[7] The factor most likely predisposing to abdominal bulge is the removal of a portion of the anterior rectus sheath.[7,8] This is because excision of a portion of the anterior rectus sheath results in an alteration of the normal contour of the abdominal wall. This altered dynamic renders the abdominal wall susceptible to the effects of increased intra-abdominal pressure and can result in dehiscence or attenuation of the repair and a lower abdominal bulge. The risk of this event can be reduced by plication and/or reinforcement of the anterior rectus sheath with Marlex mesh as an onlay or inlay graft.[9,10]

With the DIEP flap, the anterior rectus sheath and rectus abdominis muscle are incised and repaired, with no alteration of the natural contour of the abdominal wall at the time of closure. The rectus abdominis muscle remains innervated and vascularized. Following primary closure of the anterior rectus sheath, additional plication can be performed to improve the natural abdominal contour but is not necessary to relieve tension along the repair. Despite tension-free closure, a lower abdominal bulge has been observed in a small percentage of women. The reasons for this observation are speculative, and the specific etiology remains unclear.

The purpose of this study was to evaluate a set of factors that may be responsible for the development of a lower abdominal bulge following DIEP flap harvest. Based

on our intraoperative findings at the time of bulge repair, it was clear that the anterior rectus sheath had attenuated. Therefore, factors were selected that were felt to influence the integrity of this structure. The factors evaluated included previous abdominal surgery, previous childbirth, unilateral versus bilateral DIEP flap harvest, fascial plication, use of Marlex mesh, patient age, diabetes mellitus, and tobacco use.

MATERIALS AND METHODS

This was a retrospective review of 123 women that had breast reconstruction using the DIEP flap. Included were 93 women following unilateral and 30 women following bilateral reconstruction totaling 153 flaps. The mean age for women in this study was 48.1 years (range, 32 to 69 years). The study interval was from January 2000 to January 2004. The principal author performed all the DIEP flaps to minimize any variation in harvesting and closure techniques. The occurrence of a lower abdominal bulge was based upon the observation of the surgeon and patient, as well as physical examination. A bulge is defined as a protrusion of the anterior abdominal wall without an associated fascial defect. These contour abnormalities were not present preoperatively. The appearance of an abdominal bulge following DIEP flap breast reconstruction is illustrated in Figure 1, and the appearance of the abdomen following repair of the bulge is illustrated in Figure 2. Statistical analysis was performed using the SAS System and the Fisher exact test.

Operative Technique

The operative technique for the DIEP flap has been previously described.[3,11,12] The salient aspects of the operation relevant to the abdominal wall will be reviewed. Following the transverse, supraumbilical incision, the skin and fat unit is undermined much like an abdominoplasty. The undermining extends in a cephalad direction and tapers toward the xiphoid process. The patient is flexed to 30 degrees, and the lower extent of the flap is delineated and incised. This essentially constitutes the abdominoplasty portion of the procedure.

The next portion of the procedure that can impact the abdominal wall is the paramedian incision of the anterior rectus sheath. This extends from the isolated perforator to the infero-lateral border of the rectus abdominis muscle at an oblique at angle that usually ranged between 15 and 60 degrees. This was based on the location at which the inferior epigastric artery and vein crossed the lateral border of the rectus abdominis muscle. The anterior rectus sheath lateral to the perforator was elevated off the rectus abdominis muscle to facilitate visualization of the inferior epigastric vascular arcade. The perforating vessel or vessels were dissected through a myotomy and all muscular branches of the inferior epigastric artery and vein were divided using hemoclips. The intercostal nerves innervating the rectus abdominis muscle were preserved as they entered the muscle and divided only when they crossed over the inferior epigastric vessels within the muscle.

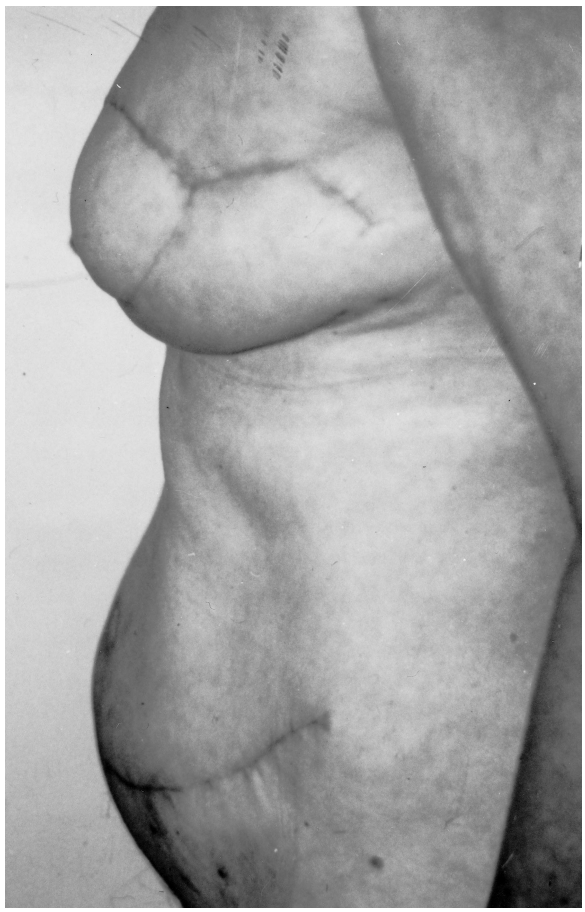

FIGURE 1. A postoperative lower abdominal bulge following bilateral flap harvest.

Following completion of the microvascular anastomosis, the abdomen was closed. One or 2 absorbable sutures were usually placed in myotomy. Primary closure of the anterior rectus sheath was performed using a braided nonabsorbable suture in an interrupted, figure-of-8 fashion. Additional suture plication of the contralateral and superior anterior rectus sheath was occasionally performed at the time of closure in women with a convex abdominal wall. This was done for cosmetic reasons to improve the natural abdominal contour. Reinforcement of the anterior sheath incision using Marlex mesh in an onlay fashion was rarely used and only when the fascia was noted to be friable.

RESULTS

The list of factors that were evaluated is provided in Table 1. A lower abdominal bulge occurred in 5 of the 123 women (4%) in this study. For the 30 women who had

FIGURE 2. Abdominal appearance following plication of the anterior rectus sheath with reinforcement of the anterior fascia with Marlex mesh.

TABLE 1. The Set of Factors That Were Evaluated as a Possible Etiology for Lower Abdominal Bulge

	All Women (n = 123)		Unilateral Women (n = 93)		Bilateral Women (n = 30)	
	No.	Percent	No.	Percent	No.	Percent
Lower abdominal bulge	5	4	3	3.2	2	6.6
Diabetes mellitus	1	0.8	1	1.1	0	0
Tobacco use	9	7.3	7	7.5	2	6.6
Prior abdominal surgery	55	44.7	40	43	15	47
Previous childbirth	95	77	71	76.3	24	80
Abdominal wall plication	49	40	36	38.7	13	43.3
Use of Marlex mesh	4	3.3	2	2.2	2	6.6

bilateral DIEP flaps, a lower abdominal bulge occurred in 2 (6.6%), and for the 93 women who had a unilateral DIEP flap, a lower abdominal bulge occurred in 3 (3.2%). Analyses of factors for the 5 women with a lower abdominal bulge are shown in Table 2. The abdominal incisions that were present preoperatively are listed in Table 3. In the 5 women who developed a lower abdominal bulge, all were repaired using a combination of fascial plication and Marlex mesh over the area of the delineated bulge. The fascial plication was vertical in 4 women and horizontal in 1 woman and was based on the length-to-width ratio of the bulge. The Marlex mesh was applied as an onlay graft. The repair resulted in elimination of the bulge on 2 women and a persistent bulge in 3 women.

Statistical analysis demonstrated no significant association between any of the variables evaluated and abdominal bulge (Table 4). However, there was a weak trend toward developing a lower abdominal bulge in women with no history of previous childbirth. The odds ratio for these women was 5.6 ($P = 0.08$).

DISCUSSION

This study was designed to evaluate a set of factors that may play a role in the development of a lower abdominal bulge following breast reconstruction with the DIEP flap. The impetus to perform this evaluation was in an attempt to understand why some women develop a lower abdominal bulge postoperatively and especially why some women have a persistent bulge despite repair. The factors evaluated all had a potential impact on the quality and integrity of the anterior abdominal wall.

There are many elements that contribute to the appearance, function, and support of the anterior abdominal wall. These include the 3 aponeurotic structures (linea alba, anterior rectus sheath, posterior rectus sheath), the 4 abdominal muscles (rectus abdominis, internal oblique, external oblique, transverse abdominis), and the superficial fascial system (SFS) of the trunk.[13–17,18] In the normal setting, there is a balance among these elements that contributes to the observed abdominal contour. Electromyography studies have demonstrated that the oblique and rectus abdominis muscles are principally involved in trunk movements and that transverse abdominis is principally involved in intraabdominal pressure production.[19,20] The collagen fibers of the rectus sheath and linea alba are principally involved in the stabilization and support of the anterior abdominal wall.[15,16] The SFS consists of fibrous septa that connect the skin to the underlying muscle fascia to create zones of adherence.[18]

Our current understanding of lower abdominal bulge is that it is principally due to the anterior rectus sheath. The basic anatomy of the anterior rectus sheath is well known and has been previously described.[13,14,17,21] More recently, detailed anatomic studies of the rectus sheath and linea alba have been performed using focal laser scanning microscopy to provide a 3-dimensional architectural description of the collagen fibers.[15,16] The general architecture of the anterior rectus sheath consists primarily of oblique interdigitating

TABLE 2. The 5 Women Who Developed a Lower Abdominal Bulge, With Reference to the Associated Factors

Patient	Age	Sides	Lower Abdominal Bulge	Diabetes	Tobacco	Full-term Pregnancy	Plication	Mesh	Abdominal Incisions
1	44	Unilateral	Yes	No	No	0	Yes	No	None
2	38	Unilateral	Yes	No	No	0	No	No	None
3	60	Unilateral	Yes	No	No	0	Yes	No	Pfannenstiel
4	40	Bilateral	Yes	No	No	2	No	No	Right lower quadrant
5	41	Bilateral	Yes	No	No	2	No	No	None

TABLE 3. The Abdominal Incisions Prior to DIEP Flap Reconstruction

	Number of Women	
Incision	Unilateral DIEP	Bilateral DIEP
Upper midline	1	0
Lower midline	5	3
Pfannenstiel	20	6
Right lower quadrant	5	2
Right upper quadrant	1	1
Laparoscopy	6	3
Lower paramedian	2	0
None	53	15

TABLE 4. Statistical Analysis Using the Fisher Exact Test

	P Value
Age	0.29
Unilateral versus bilateral	0.59
Diabetes mellitus	0.99
Tobacco use	0.62
Previous childbirth	0.08
Plication of the abdomen	0.99
Use of Marlex mesh	0.99
Prior abdominal operations	0.99

collagen fibers. Craniocaudal analysis demonstrates a thickening of the anterior rectus sheath and a thinning of the posterior rectus sheath caudally. Studies have demonstrated that the thickness, density, and elastic coefficient of the collagen fibers may be predisposing factors in the development of a bulge or hernia.[22,23]

The role of the anterior rectus sheath and linea alba in regard to the development of incisional hernias and bulge is well appreciated. In a study comparing tissue strength of 6 laparotomy incisions that included midline and paramedian incisions, Tera and Aberg[24] found that the strongest closure was obtained following a midline incision and the weakest closure was obtained following a paramedian incision. This observation is significant because the paramedian incision is routinely used for breast reconstruction using abdominal flaps. This suggests that the orientation and location of the fascial incision are important factors that may be responsible for lower abdominal bulge following DIEP flap reconstruction.

Prior studies have indicated that attenuation or dehiscence of the anterior rectus sheath at the site of the paramedian incision is the principle etiology of the lower abdominal bulge.[7,8] This conclusion was based on the operative assessment of the anterior rectus sheath at time of bulge/hernia repair and the observation that removal of increasing amounts of the rectus abdominis muscle did not predispose to a lower abdominal bulge.[7] Nahas et al,[25] in a cadaver study, defined the traction index as the force required to pull the anterior rectus sheath towards the midline following aponeurotic incisions. With the TRAM flap, the traction index is increased because of the fascial deficit. With the DIEP flap, the traction index is negligible because there is no fascial deficit. Despite this, lower abdominal bulge has been observed with the DIEP flap even in the absence of tension along the fascial incision. The most likely explanations involve the durability of the anterior rectus sheath repair that can result in dehiscence or attenuation.

The durability of the anterior rectus sheath and its response to suture plication has been previously evaluated. Two studies with similar results but conflicting conclusions have been performed. Netscher et al[26] have demonstrated that musculoaponeurotic plication using number 1 braided nonabsorbable sutures for diastasis is effective, durable, and long lasting. In 5 of 9 patients following abdominoplasty, there was radiographic evidence of fascial separation measuring 1 to 3 cm. This separation did not progress after 3 weeks, and the esthetic appearance of the abdomen was not compromised at 1 year. van Uchelen et al,[27] in a long-term follow-up study (mean, 64 months), have demonstrated that standard plication of the diastasis led to residual or recurrent diastasis in 40% of women. In 40 of 70 women that had vertical plication of the anterior rectus sheath, ultrasonic evaluation was performed

and demonstrated a diastasis in 16 women that ranged from 1 to 4.2 cm. These studies demonstrate that the anterior rectus sheath is susceptible to deforming forces, can attenuate over time, and may become clinically evident.

The role of pregnancy and its sequelae on the anterior abdominal wall has been considered but rarely studied. Experimental studies have demonstrated a decrease in the cross-sectional area of the rectus abdominis and transverse abdominis muscles, a decrease in muscle fiber diameter, and an increase in type I fibers.[28,29] Nahas[30] has classified the musculoaponeurotic deformity associated with pregnancy as type A and type B. These include women with a rectus diastasis with or without laxity of musculoaponeurotic layer. Clinical studies have demonstrated that pregnancy can result in a stretch-induced denervation of the abdominal musculature, resulting in a "flabby abdomen."[31] The connective tissue response to pregnancy has been studied by Axer et al,[16] who found that in 5 of 6 women, the infraumbilical linea alba was less thick and more wide than in males. All 5 of these women had borne children, and the sixth woman had not.

The results of this study were interesting in that none of the explanatory variable were significantly associated with the occurrence of a lower abdominal bulge. Full-term pregnancy and previous childbirth appeared to have a beneficial effect in the prevention of a postoperative lower abdominal bulge. The odds ratio of 5.6 shows that women who had not borne children had 5.6 times higher rates of having a postoperative bulge compared with those women who had borne children. Although difficult to explain based on the results of previous studies, it may be that the stress applied on the collagen lattice of the anterior rectus sheath results in an increase in strength to provide the necessary support that is needed during pregnancy. Following the pregnancy, this may provide a more durable anterior rectus sheath that is less susceptible to attenuation following the incision and repair.

Additional information about the anterior rectus sheath was obtained in the 5 women that had a repair of the lower abdominal bulge. In 3 women (60%), there was an improved but persistent lower abdominal bulge. This fact demonstrates that in some women there may be an inherent weakness of the anterior rectus sheath that predisposes to abdominal bulge formation. In these women, the anterior rectus sheath was flaccid throughout. Of these, 2 had never had a full-term pregnancy and 1 was plicated horizontally. It may be that attenuation of the anterior rectus sheath occurs in a craniocaudal direction rather than in a lateral direction, rendering a horizontal plication more prone to failure.

In summary, none of the factors analyzed were significantly associated with a lower abdominal bulge. This leads to the conclusion that the formation of a postoperative bulge is a random event and that it can potentially occur in anyone. Recommendations for the prevention and treatment of lower abdominal bulge following DIEP flap reconstruction include careful intraoperative assessment of the anterior rectus sheath for signs of weakness or laxity, use of an adjuvant material such as Marlex for reinforcement of the sheath when friable, and vertical plication of the anterior rectus sheath for bulge correction.

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