

Donor Site Sensitivity After Breast Reconstruction With Deep Inferior Epigastric Artery Perforator Flap

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Abstract: The aim of this study was to examine pressure sensitivity at the donor site after breast reconstruction with deep inferior epigastric artery perforator (DIEAP). In a cross-sectional survey, 2 groups of patients were analyzed. The DIEAP group consisted of 30 women who had previously had secondary breast reconstruction with DIEAP flap after mastectomy for breast cancer. The control group consisted of 7 women with no previous abdominal incisions planned for secondary breast reconstruction with DIEAP. Pressure thresholds were tested within the margins of the abdominal wall using Semmes-Weinstein monofilaments. In the DIEAP group a pattern of higher pressure thresholds was observed in the proximity of the scar. Comparing the 2 groups, significant higher pressure thresholds were found in the DIEAP group in the scar on both sides and in the midline from the scar to the umbilical level. Our data show that the abdominoplasty performed during breast reconstruction with DIEAP reduces cutaneous sensitivity in the donor site area.

Key Words: breast, reconstruction, DIEAP flap, abdominoplasty, cutaneous sensitivity, Semmes-Weinstein monofilaments

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Since the introduction of the free transverse rectus abdominis myocutaneous (TRAM) flap in 1979,¹ more sophisticated free flaps have been developed and added to the ladder of reconstructive breast surgery. The popularity of free microvascular transplants in breast reconstruction has grown considerably over the years. The reason is a better cosmetic result and more satisfied patients.^{2,3} The deep inferior epigastric artery perforator (DIEAP) flap is the gold standard of free flaps in breast reconstruction. The superiority of this flap compared with other free flaps is the aesthetic benefits achieved at the donor site.

An abdominoplasty is performed as a standard procedure to close the donor defect after raising the DIEAP flap. The undermining of the panniculus is likely to affect cutaneous sensitivity of the abdominal wall due to denervation of the nerve fibers to the skin.^{4,5} However, evaluation of cutaneous sensitivity at the donor site after DIEAP procedure has not yet been reported.

The aim of this study was to evaluate the effect of undermining on skin sensitivity after abdominoplasty in breast reconstruction with DIEAP flaps using Semmes-Weinstein monofilaments. Positive findings would help plastic surgeons provide their patients with

more detailed information on donor site morbidity prior to reconstruction.

PATIENTS AND METHODS

Study Design

In a cross-sectional survey of patients having their breasts reconstructed with a DIEAP procedure, pressure thresholds were tested within the margins of the abdominal wall.

Patients

Thirty women were included in the DIEAP group of this study. They had previously had abdominoplasty performed during secondary breast reconstruction with DIEAP flap after mastectomy for breast cancer. The DIEAP reconstructions were performed by the microsurgical team in our department during a 5-year period (2001–2005 inclusive) according to a standard procedure.⁶ The mean (SD) age at the time of testing for abdominal sensitivity was 54.8 (7.3) years. The mean (SD) time from surgery to abdominal sensory evaluation was 3.5 (1.4) years. The control group consisted of women planned for secondary breast reconstruction with DIEAP flap. These women had previously been mastectomized due to breast cancer. Seven consecutive patients with scar-free abdominal skin were selected and examined during hospitalization on the day prior to surgery. The mean (SD) age was 52.4 (9.2) years. Clinical details are shown in Table 1.

Pressure Threshold Measurements

Each subject was placed in the supine position on an examining table. In the DIEAP group, the midline of the abdomen was marked from 2 cm below the scar to the xiphisternum. In addition, a parallel line was marked 10 cm from the midline on both sides from 2 cm below the scar to the costal arch. A point was then placed every 2 cm on each line (Fig. 1). The patients were blindfolded. Each point including the umbilicus was evaluated for pressure thresholds of slowly adapting fibers with Semmes-Weinstein monofilaments⁷ to test the Merkel cell complex starting below the scar moving superiorly. A reference point 15 cm above the nipple in the midclavicular plane of one breast was also tested. A kit including 5 monofilaments with increasing target force (0.07 g = normal touch; 0.4 g = diminished light touch; 2 g = diminished protective sensation; 4 g = loss of protective sensation; 300 g = deep pressure sensation) developed to evaluate pressure thresholds in the hand (Touch-Test 5 Piece Hand Kit from North Coast Medical, Inc, Morgan Hill, CA) was used. All test results were categorized according to the target force applied (0 = normal touch; 1 = diminished light touch; 2 = diminished protective sensation; 3 = loss of protective sensation; 4 = deep pressure sensation; 5 = no deep pressure sensation). The monofilament was pressed at a 90-degree angle against the skin until it bowed and held in place for approximately 1.5 seconds and then removed. Each point was evaluated starting with the lowest target force moving one category up until the patient sensed the pressure. Testing was repeated until 2 identical consecutive values were obtained in each point. In the control group the abdomen was marked as outlined above according to an

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TABLE 1. Details of Patients

	DIEAP (N = 30)		Control (N = 7)		P Value
	Mean (SD)	Range	Mean (SD)	Range	
Age at examination; y	54.8 (7.3)	(37.4–69.0)	52.4 (9.2)	(42.5–66.1)	0.453
Body mass index; kg/m ²	25.9 (3.2)	(19.5–32.3)	28.3 (3.9)	(23.7–35.4)	0.099
Education; n (%)					*
Primary and secondary school	5 (17)		2 (29)		
High school	18 (60)		2 (29)		
College	7 (23)		2 (29)		
University	0		1 (14)		
Coexisting conditions; n (%)					*
None	15 (50)		0		
Hypertension	5 (17)		0		
Cardiovascular	0		0		
Diabetes mellitus	3 (10)		1 (14)		
Other	8 (27)		1 (14)		
Smoking; n (%)	11 (37)		2 (29)		1.000
Adjuvant therapy; n (%)					
Chemotherapy	13 (43)		4 (57)		0.680
Radiotherapy	12 (40)		4 (57)		0.437
Axillary node dissections; n (%)	22 (73)		4 (57)		0.360
Time between mastectomy and examination; y	8.1 (5.4)	(2.9–32.8)	4.1 (5.0)	(1.7–15.4)	0.080
Time between breast reconstruction and examination; y	3.6 (1.4)	(1.1–5.6)			

*Numbers are too small for statistical testing.

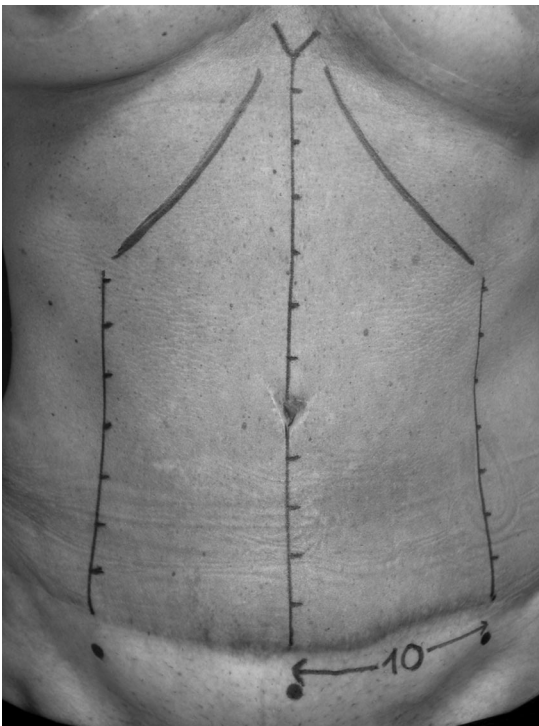


FIGURE 1. Sensitivity test pattern for the donor site after breast reconstruction with a DIEAP flap. Pressure thresholds were tested with Semmes-Weinstein monofilaments for every 2 cm along the midline including the umbilicus and 10 cm parallel to this on both sides.

imaginary curvilinear scar based on the mean distance between the scar and the umbilicus (7.4 cm) in the DIEAP group. Testing with Semmes-Weinstein monofilaments was carried out according to the routines for the DIEAP group. The testing was carried out by the first author (T.T.T.). All tests were done in a quiet room.

Statistical Analysis

Descriptive statistics are presented using means with standard deviations (SDs) or numbers with percentages. Groups were compared using the *t* test or Fisher exact test where appropriate. The mean pressure threshold was calculated as the mean of categories designated to each point. We compared corresponding points of pressure thresholds within the abdominal margins using Mann-Whitney *U* test. Furthermore, a correlation analysis was carried out comparing pressure thresholds with age, body mass index, smoking, and follow-up time in the DIEAP group. We accepted probabilities of less than 0.05 as significant. We used the Statistical Package for the Social Sciences (SPSS version 12.0, SPSS Inc, Chicago, IL) for data analyses.

RESULTS

Descriptive data for the DIEAP and the control group are shown in Table 1. No statistically significant differences were found between the 2 groups. In the DIEAP group, the mean (SD) length of the abdominal scar was 39.4 (4.7) cm. The mean (SD) distance between the scar and the umbilicus was 7.4 (1.5) cm. The mean (SD) length of the vertical lines measuring from the scar were, respectively, 21.4 (2.0) cm in the midline, 13.6 (2.5) cm to the right, and 13.6 (2.2) cm to the left. The mean (SD) pressure threshold for the reference point was 0.7 (0.6) in the DIEAP group and 0.9 (0.4) in the control group ($P = 0.608$).

TABLE 2. Evaluation of Abdominal Sensibility. Mean (SD) Pressure Thresholds Tested With Semmes-Weinstein Monofilaments

Measure Points	Distance From Scar (cm)	DIEAP		Control		P Value	
		Pressure Threshold; Mean (SD)	N	Pressure Threshold; Mean (SD)	N		
Right	-2	1.8 (1.0)	30	1.1 (0.4)	7	0.100	
	0	2.9 (1.2)	29	0.9 (0.4)	7	0.000	
	2	1.5 (1.0)	30	1.0 (0)	7	0.185	
	4	1.3 (1.2)	30	1.0 (0)	7	0.690	
	6	1.3 (1.1)	30	1.0 (0.6)	7	0.690	
	8	1.1 (0.9)	30	1.0 (0.6)	7	0.955	
	10	0.8 (0.8)	29	1.3 (0.5)	7	0.142	
	12	0.9 (0.8)	22	1.1 (0.4)	7	0.304	
	14	1.2 (0.8)	13	1.0 (0)	5	0.633	
	16	1.0 (0.8)	4	1.3 (0.5)	4	0.686	
	18	1.0 (0)	2	1.0 (1.0)	3	1.000	
	Midline	-2	2.4 (1.2)	30	1.4 (0.5)	7	0.021
		0	4.1 (0.7)	30	1.3 (0.5)	7	0.000
2		3.5 (1.3)	30	1.3 (1.0)	7	0.000	
4		2.9 (1.4)	29	0.9 (0.9)	7	0.001	
6		3.2 (1.4)	25	0.9 (0.7)	7	0.000	
8		3.2 (1.4)	17				
10		2.4 (1.3)	26	1.3 (0.8)	7	0.054	
12		1.9 (1.4)	28	1.1 (0.4)	7	0.171	
14		1.4 (1.3)	30	1.0 (0)	7	0.435	
16		1.0 (0.9)	30	1.0 (0.6)	7	0.865	
18		0.7 (0.7)	29	0.9 (0.7)	7	0.584	
20		0.6 (0.7)	25	0.8 (0.8)	6	0.391	
22		0.6 (0.7)	10	0.8 (0.4)	5	0.513	
24	1.0 (1.4)	2	1.0 (0)	4	1.000		
Left	-2	1.7 (0.7)	30	1.4 (0.5)	7	0.370	
	0	2.7 (1.2)	30	1.1 (0.4)	7	0.001	
	2	1.5 (0.9)	30	0.9 (0.4)	7	0.071	
	4	1.2 (1.1)	30	0.9 (0.4)	7	0.531	
	6	1.0 (0.8)	30	0.9 (0.4)	7	0.690	
	8	0.6 (0.6)	30	0.9 (0.7)	7	0.413	
	10	0.6 (0.7)	29	1.3 (0.8)	7	0.054	
	12	0.7 (0.7)	23	1.2 (0.4)	6	0.142	
	14	0.8 (0.8)	13	1.2 (0.4)	5	0.387	
	16	1.0 (0)	4	1.0 (0.8)	4	1.000	
	18	1.0 (0)	1	1.0 (0)	3	1.000	
	Umbilicus		3.7 (1.2)	30	1.9 (0.7)	7	0.001
	Reference point		0.7 (0.6)	30	0.9 (0.4)	7	0.608

In the DIEAP group, either deep pressure sensation $n = 9$ (30%) or no deep pressure sensation $n = 21$ (70%) was registered as the highest threshold value in one or more measure points. The highest threshold found for the controls was diminished protective sensation in 6 cases (86%) and loss of protective sensation in one case (14%). In total, 36 corresponding points on the abdominal skin were compared in the 2 groups (Table 2). In the DIEAP group the mean (SD) pressure thresholds ranged from 0.6 (0.6) to 4.1 (0.7). In the control group the mean (SD) varied from 0.8 (0.4) to 1.9 (0.7). Comparing the 2 groups, statistically significant and higher pressure thresholds were found in the DIEAP group in the scar on both sides and in the midline according to the measure points at -2 cm, 0 cm, 2 cm, 4 cm, 6 cm, and the umbilicus. No correlation was found comparing pressure thresholds with age,

body mass index, smoking, and follow-up time in the DIEAP group.

DISCUSSION

The sensation of the abdominal skin is partly provided by the intercostal nerves. In a cadaver dissection study, Duchateau et al⁸ showed that the terminal branches of the 6 lower intercostal nerves penetrate the deep face of the rectus muscle in the middle portion resulting in segmental motor nerve supply and overlying sensitive innervation through perforator branches distributed to the skin. Through detailed anatomic mapping Yap et al⁹ demonstrated multiple ramifications of these perforator nerves creating a complex sensitive network to the anterior abdominal wall

resulting in dermatomal overlap. This network is probably damaged when performing an abdominoplasty resulting in decreased sensitivity caused by the severing of cutaneous nerves when undermining the panniculus.^{4,5}

The DIEAP flap is an ideal solution for autologous breast reconstruction. The result is a better aesthetic outcome and higher patient satisfaction.³ Furthermore, the donor site morbidity is lower.^{10–12} However, no data concerning donor site sensitivity after DIEAP procedure has been published to date.

The purpose of this study was to evaluate the donor site sensitivity after breast reconstruction with DIEAP flaps. Comparing a group of DIEAP patients with controls, higher pressure thresholds were found in the DIEAP group in the scar on both sides and in the midline from the scar to the umbilical level. No correlation was found comparing pressure thresholds with age, body mass index, smoking, and follow-up time in the DIEAP group.

Our results are in accordance with previous studies. Farah et al⁴ did a study on sensibility after abdominoplasty. Pressure sensitivity was performed with a method comparable to the Semmes-Weinstein monofilaments. Testing was carried out in 12 areas covering the abdominal area. Statistically significant differences were found in all areas compared with the control group with least sensitivity in the hypogastric area between the scar and the umbilicus. Fels et al⁵ did a similar study where pressure sensitivity was evaluated with the Pressure-Specified Sensory Device (PSSD, Sensory Management Services, LLC, Baltimore, MD) in 9 areas. A statistically significant decrease of cutaneous pressure thresholds was noted throughout the entire abdominal wall in the operative group. Like in the study by Farah et al,⁴ the least sensitivity was located in the lower central part. We also found that the least sensitive area was in the lower central part. However, in contrast to Farah et al⁴ and Fels et al⁵ we were not able to detect any statistical significance outside this area excluding the scar line. In light of this, we speculate that the undermining of the panniculus in the classic abdominoplasty is more extensive compared with the undermining performed during the DIEAP procedure resulting in a greater cutaneous denervation of the panniculus. According to our clinical experience this makes sense as the area of the excess skin discarded during a classic abdominoplasty is considerably larger than the area of the DIEAP flap. This presupposes a more substantial undermining of the panniculus to obtain a tension-free closure of the abdominal defect.

Spear et al¹³ examined abdominal sensitivity after breast reconstruction with pedicled TRAM. The evaluation was also carried out with Semmes-Weinstein monofilaments. Similar to our study, the least sensitive area was located between the scar and the umbilicus. In contrast to our study, they also found statistically significant higher threshold values in the rest of the abdominal wall compared with controls. This can also be explained by a more far-reaching undermining due to the tunnelling of the flap suggesting that the donor site sensitivity is more pronounced in pedicled TRAM compared with DIEAP.

As pointed out by Farah et al,⁴ the hypogastric area becomes the distal-most point of cutaneous innervation of the abdominal wall following abdominoplasty. The direct innervation is severed by undermining the area. The indirect innervation is partly affected by undermining the neighboring areas and partly by the skin incision, which damages the nerve connections from the pubic area and upper thighs. On the other hand the neighboring areas are supplied by nerve connections coming from the surrounding tissues. This explains why the lowest degree of pressure sensitivity is found in the hypogastric region as demonstrated in our and other studies.^{4,5,13} It also implicates

that undermining should be limited to protect the perforator neurosomes and thereby preserve the donor site sensitivity.

Semmes-Weinstein monofilaments have been used as a measuring tool for evaluation of skin sensitivity after various reconstructive procedures of the breast.^{13–19} Each monofilament is individually calibrated to deliver its targeted force within a 5% standard deviation. However, the test results can be difficult to reproduce and varies with the examiner and the variations of the elasticity resulting from humidity, temperature, and different manufacturers.⁵ However, in this study these variables were kept constant.

We are aware of the problem raised by statistical testing when comparing multiple data. We performed 37 statistical comparisons of correlated outcomes using the Mann-Whitney *U* test. The most conservative approach would be to adjust for multiple comparisons using the Bonferroni correction and hence reduce the critical value to $\alpha/37$, ie, $0.05/37 = 0.0013$. Based on this correction, the differences found at the umbilicus, in the right and left part of the scar, and at the lower part of the midline still showed significant values between the 2 groups. Nevertheless, using full Bonferroni correction in this study would probably be too conservative because of the multiple correlated outcomes.^{20,21}

This study is the first to evaluate pressure sensitivity of the abdominal wall after DIEAP procedure. Sensory deficit was only found in the scar and in the midline up to the umbilical level. This information can be used in advising patients preoperatively of anticipated sensory changes. Future studies are required to evaluate the clinical importance of the sensory changes through quality-of-life assessments.

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