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Tyge T. Tindholdt^{ab}; Kim A. Tønseth^b

^a Department of Plastic Surgery, Skien, Sykehuset Telemark, Norway

^b Department of Plastic Surgery, Oslo, Rikshospitalet, Norway

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ORIGINAL ARTICLE

Spontaneous reinnervation of deep inferior epigastric artery perforator flaps after secondary breast reconstruction

TYGE T. TINDHOLDT^{1,2} & KIM A. TØNSETH²

¹Department of Plastic Surgery, Sykehuset Telemark, Skien, ²Department of Plastic Surgery, Rikshospitalet, Oslo, Norway

Abstract

The deep inferior epigastric artery perforator (DIEAP) flap is the gold standard of free flaps in breast reconstruction. However, until now little attention has been paid to reinnervation of the flap. The aim of this study was to examine the spontaneous reinnervation of the DIEAP flap after breast reconstruction. The study was cross-sectional, and included 29 women who had all previously had secondary reconstruction with a DIEAP flap after mastectomy for breast cancer. Pressure thresholds were analysed on the skin island of the flap using Semmes-Weinstein monofilaments. The measurements showed measurable sensation in 29 of the 30 flaps. Nine patients had normal or diminished light touch in one or more areas. We also found significant better pressure sensitivity when the medial was compared to the lateral side and the inferior to the superior side of the flap. Our data showed that DIEAP flaps reinnervate after breast reconstruction although there is no sensory nerve repair. We suggest that nerve ingrowth takes place from the sides and this seems to be more pronounced in the inferomedial part of the flap.

Key Words: Breast, reconstruction, DIEAP flap, sensitivity, reinnervation, Semmes-Weinstein monofilaments

Introduction

Breast reconstruction with autologous tissue has developed tremendously since the introduction of the free transverse rectus abdominis myocutaneous (TRAM) flap in 1979 [1]. New methods are continually being introduced, and constantly being improved. The result is a better aesthetic outcome, lower donor site morbidity, and more satisfied patients.

Many aspects of breast reconstruction with autologous tissue have been investigated but only limited attention has been paid to reinnervation of flaps. Lehmann et al. studied this in myocutaneous flaps after breast reconstruction with TRAM and latissimus dorsi flaps [2], and found that sensitivity returned spontaneously after both procedures. Other groups have looked at reinnervation in pedicled or

free TRAM flaps, or both [3–8], and all reported varying degrees of spontaneous reinnervation.

So far only one study has been published about reinnervation in DIEAP flaps [8]. Blondeel et al. compared patients who had reconstructions with DIEAP flaps with or without sensory nerve repair. Both groups had a high degree of reinnervation, but the entire reconstructed breast was tested including both the skin island of the flap and the remaining breast skin. The aim of the present study was to investigate spontaneous reinnervation in non-innervated DIEAP flaps limited to the skin island.

Patients and methods

Study design

In a cross-sectional survey of patients having their breasts reconstructed with a DIEAP procedure, pressure threshold measurements were made in the horizontal and vertical planes of the flap.

This study was presented at the 82nd Annual Congress of the Norwegian Society of Plastic Surgery, Oslo, Norway, 26th October 2006.

Correspondence: Tyge Tind Tindholdt, Department of Plastic Surgery, Rikshospitalet, NO 0027 Oslo, Norway. Tel: +47-23 07 41 85. Fax: +47-23 07 42 63. E-mail: tyge.tindholdt@rikshospitalet.no

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Patients

Twenty-nine women were included in the study who had all previously had secondary reconstruction with a standard DIEAP flap [9] after modified radical mastectomy for breast cancer. They were randomly selected from a database of patients who had had DIEAP flap reconstructions in our department during a five year period (2001–2005 inclusive). Only one had had bilateral reconstruction. Sensory nerves were not repaired in any case. At the time of investigation the patients' ages ranged from 37 to 69 years (mean (SD) 55 (7)). The patients were examined after 1.1 to 5.6 years (mean (SD) 3.5 (1.4)) after the reconstruction. Clinical details are shown in Table I.

Pressure threshold measurements

The skin island of the DIEAP flap was marked with a horizontal and a vertical axis crossing each other in the centre making medial, lateral, inferior, and superior lines. Each line was then divided into points for every 2 cm starting at the scar (Figure 1). The patient was blindfolded. Each point was evaluated for pressure thresholds of slowly adapting fibres with Semmes-Weinstein monofilaments to test the Merkel cell complex [10]. Testing started at the scar moving along each line towards the centre of the skin island. The centre and a reference point placed 15 cm superiorly to the opposite nipple were also tested. Testing was repeated until identical consecutive values were obtained in each point.

Table I. Details of patients. Data are mean (SD) (range) unless otherwise stated.

Age at examination (years)	54.5 (7.2)	(37.4–69.0)
Body mass index (kg/m ²)	25.9 (3.3)	(19.5–32.3)
Education (number (%))		
Primary and secondary school	4	(14)
High school	18	(62)
College	7	(24)
University	0	
Coexisting conditions (number (%))		
None	17	(59)
Hypertension	5	(17)
Diabetes mellitus	2	(7)
Cardiovascular	0	
Other	8	(28)
Smoking (number (%))	11	(38)
Adjuvant treatment (number (%))		
Chemotherapy	13	(45)
Radiotherapy	11	(38)
Axillary gland procedures (number (%))	22	(76)
Time between mastectomy and examination (years)	8.1 (5.5)	(2.9–32.8)
Time between breast reconstruction and examination (years)	3.5 (1.4)	(1.1–5.6)



Figure 1. Sensitivity test pattern for DIEAP breasts. Pressure threshold was tested with Semmes-Weinstein monofilaments for every 2 cm starting at the scar line along the medial, the lateral, the inferior, and the superior lines.

A kit including five 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 only) developed to evaluate pressure thresholds in the hand (Touch-TestTM 5 Piece Hand Kit, North Coast Medical, Inc.) was used. The monofilament was pressed at a 90° angle against the skin until it bowed and held in place for roughly 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. The first author did all the tests. All test results were categorised according to the most target force applied to each point (0 = normal touch; 1 = diminished light touch; 2 = diminished protective sensation; 3 = loss of protective sensation; 4 = deep pressure sensation; 5 = no pressure sensation). All tests were done in a quiet room.

Statistical analyses

We used the Statistical Package for the Social Sciences (SPSS version 12.0) for data analyses. The mean pressure threshold was calculated as the mean of categories designated for each point. We compared corresponding points of pressure thresholds on the medial and the lateral side, and on the inferior and the superior side using Wilcoxon's signed rank test. We accepted probabilities of less than 0.05 as significant.

Results

The mean (SD) height of the skin island was 10.9 cm (3.2) and the mean (SD) width was 21.5 cm (4.3). The mean (SD) pressure threshold for the reference point representing normal skin was 0.7 (0.6). The

mean pressure threshold for the reference point was significantly different from those of each testing point of the skin island of the DIEAP flap.

All patients except one had measurable pressure sensitivity varying from normal to deep pressure sensation when testing the skin island of the flap. Only one patient had no pressure sensation at all when the test points of the scar line were left out. Nine breasts (30%) were categorised as having normal or diminished light touch sensation at one or more test points (Figure 2). Fourteen breasts (47%) were categorised as having diminished protective or loss of protective sensation, and seven breasts (23%) with either deep pressure sensation only or no sensation at all. There was a tendency towards increasing pressure thresholds moving from the periphery of the skin island towards the centre of the flap.

On the horizontal axis significantly lower pressure threshold values were found medially 0, 2, and 4 cm from the scar compared with the lateral side (Table II). In the vertical plane lower thresholds were found inferiorly at all testing points compared with the superior side of the flap. Significance could be calculated only in the scar and 2 cm from the scar line (Table III).

Discussion

The sensation of the breast envelope is provided by an overlap of sensory nerves. The medial part of the breast is innervated by the II to the VI intercostal nerves. The lateral innervation comes from the III to the VI intercostal nerves, and the superior part of the breast is innervated by the supraclavicular branches of the cervical plexus.

Spontaneous reinnervation of a flap after breast reconstruction with autologous tissue has been

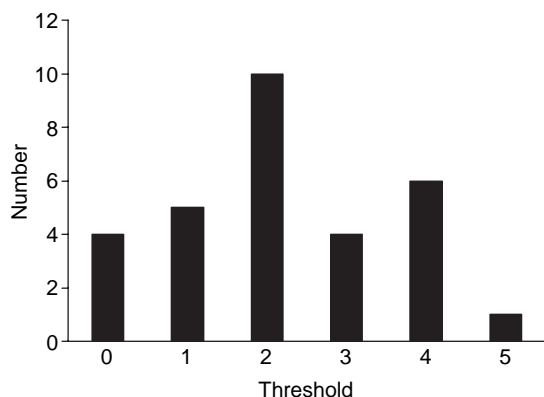


Figure 2. DIEAP breasts categorised according to the lowest pressure threshold recorded on the skin island of the flap excluding the scar line (0 = normal touch; 1 = diminished light touch; 2 = diminished protective sensation; 3 = loss of protective sensation; 4 = deep pressure sensation; 5 = no sensation).

described by several authors [2–8], but so far no one has managed to elucidate the underlying mechanism. Lehmann et al. reported a histological study of cutaneous and subcutaneous parts of the transferred flap but failed to detect any neurofilaments [2]. However, Turkof et al. suggested that sprouting axons primarily use the empty neurilemmal sheaths of the flap as conduits during regeneration [11]. They investigated sensory recovery in myocutaneous non-innervated free flaps to the lower leg. Whether spontaneous ingrowth of sensory nerves is established from the skin margins of the flap or from the deep surface of the mastectomy bed is still not clear. However, Place et al. and Shaw et al. concluded that the sensory return seems to come from both [6,7].

We evaluated the sensitivity to pressure on the skin island of non-innervated deep inferior epigastric artery perforator flaps in secondary breast reconstruction after mastectomy. We confirmed that autologous tissue used in breast reconstruction can reinnervate spontaneously. We also showed that sensitivity to pressure was better in the medial and inferior part of the skin island than in the lateral and superior part of the flap. We used a kit of Semmes-Weinstein monofilaments developed to examine sensitivity to pressure in the palm of the hand. However, our reference point was placed on normal skin of the breast. This might explain why we found a mean pressure threshold for the reference point (0.7) that was slightly higher compared with normal skin in the hand (0).

Several studies have investigated sensitivity to pressure in autologous breast reconstruction with Semmes-Weinstein monofilaments [3,5–8]. Two measured pressure thresholds within the skin island of TRAM flaps [3,5]. As we have shown, both Slezak et al. [3] and Liew et al. [5] found the best sensory recovery for constant touch in the inferomedial part of the flap. Other investigators included the whole

Table II. Mean (SD) pressure thresholds for DIEAP breasts in the horizontal plane (medial to lateral) tested with Semmes-Weinstein monofilaments.

Distance from scar (cm)	Pressure threshold		N	p value
	Medial	Lateral		
0	3.3 (0.9)	3.8 (1.3)	30	0.05
2	2.7 (1.6)	3.8 (1.1)	30	0
4	3.0 (1.5)	4.0 (1.2)	30	0.001
6	3.6 (1.3)	3.9 (1.3)	29	0.4
8	4.0 (1.3)	3.9 (1.4)	25	0.8
10	4.5 (0.7)	4.2 (1.0)	19	0.1
12	4.8 (0.4)	4.6 (0.5)	5	0.3
14	5.0 (0)	5.0 (0)	1	1.0

Table III. Mean (SD) pressure thresholds for DIEAP breasts in the vertical plane (lower to upper) tested with Semmes-Weinstein monofilaments.

Distance from scar (cm)	Pressure threshold		N	p value
	Lower	Upper		
0	3.1 (1.2)	3.9 (1.1)	30	0.009
2	3.6 (1.4)	4.5 (0.7)	27	0.002
4	4.0 (1.3)	4.3 (1.3)	23	0.3
6	4.3 (0.9)	4.5 (0.7)	9	0.4

skin envelope of the reconstructed breast, dividing the breast mound into quadrants [6–8]. Place et al. examined patients who had reconstruction with pedicled TRAM flaps [6]. Like us, they found that the central portions of the flap had the least sensory recovery, but they found no difference between medial and lateral. Although the differences were not significant, Shaw et al. [7] found better sensation laterally and superiorly, whereas Blondeel et al. [8] found the lowest thresholds for non-innervated free TRAM and DIEAP flaps in the medial half of the breast with slightly better sensory recovery superiorly. The latter also supported our findings of the highest thresholds centrally.

Our results compare quite closely with those of Blondeel et al. [8]. However, we found considerable differences between our patients and the women whose reconstructions were with non-innervated DIEAP flaps by Blondeel et al. [8]. We examined only patients having secondary breast reconstruction after modified radical mastectomy. Blondeel et al. included both primary and secondary reconstructions. Women who had reconstructions after skin-sparing mastectomy (46%) were also included in the same group. In these cases the flaps were buried in a subcutaneous pocket. Pressure thresholds were therefore measured on remaining breast skin, in contrast to abdominal skin in our reconstructions. This might explain the minor differences between the sensory recovery in the inferosuperior axis in the two studies. Our study included more than twice as many reconstructions. In addition, our follow-up time was more than 21 months longer. Finally, we measured pressure thresholds at up to as many as 21 points within the same flap, whereas Blondeel et al. tested the reconstructed breast in five points corresponding to each quadrant and the central area of the flap [8].

Our data have shown that DIEAP flaps reinnervate after breast reconstruction in the absence of sensory nerve repair. We suggest that nerves ingrow from the sides and that this seems to be more pronounced in the inferomedial part of the flap. Further analyses will be required to clarify whether factors such as age, radiotherapy, and duration of follow-up influence the degree of sensory recovery in DIEAP flaps. Future studies are also required to compare the effects of primary and secondary reconstructions. Finally, efforts should be made to compare sensory recovery in various free adipocutaneous flaps as part of finding ideal donor sites for breast reconstruction.

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