Evaluation of Abdominal Sensibility after TRAM Flap Breast Reconstruction

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One commonly expressed concern regarding transverse rectus abdominis myocutaneous (TRAM) flap breast reconstruction surgery is the return of sensation to the abdomen. Although many studies have focused on abdominal wall muscle incompetence or herniation, there is limited literature discussing postoperative abdominal sensation. The purpose of this study was to assess abdominal sensation a minimum of 1 year after pedicled TRAM flap surgery for breast reconstruction.

Twenty-five female patients who underwent TRAM flap breast reconstruction a minimum of 1 year before the study were compared with 10 female volunteer controls. Subject and control abdomens were specifically divided into 12 zones, then assessed for superficial touch, superficial pain, temperature, and vibration using various techniques. Fischer's exact test was used for analysis with the p value set at $p = 0.05$. The degree to which superficial touch was affected was then tested using Semmes-Weinstein monofilaments. Student's t test was used for analysis with the p value set at $p = 0.05$.

For all four sensory modalities, subjects were found to have decreased sensation in zones 5 and 8, the supraumbilical and infraumbilical regions. This was statistically significant. When assessed with Semmes-Weinstein monofilaments, the sensation of the subjects' abdomens was significantly decreased compared with controls. Significance was found in all zones.

This study clearly demonstrates that there is a significant and persistent reduction in abdominal sensibility following TRAM flap surgery. The distribution of the deficits is consistent and involves the midline supraumbilical and infraumbilical regions.

The TRAM flap has become the procedure of choice for postmastectomy autogenous breast reconstruction. It provides the plastic surgeon with a relatively safe, reliable, and aesthetically pleasing method of breast reconstruction. Since its inception, the TRAM flap and its abdominal closure have undergone numerous modifications designed to minimize donor-site morbidity and create a natural-looking breast. In addition to creating an aesthetically pleasing breast, the TRAM flap has the potential advantage of postoperative improvement in abdominal contour. (*Plast. Reconstr. Surg.* 106: 1300, 2000.)

One commonly expressed concern regarding transverse rectus abdominis myocutaneous (TRAM) flap surgery is the return of sensation to the abdomen. Traditionally, donor-site morbidity has been studied with respect to incompetence or herniation.[1] To date, there has been a paucity of literature discussing abdominal sensation after TRAM flap surgery.

The purpose of this study was to assess subjectively and quantify objectively abdominal sensation a minimum of 1 year after pedicled TRAM flap surgery for breast reconstruction.

Patients and Methods

Study Sample

The study sample included 25 women who underwent TRAM flap breast reconstruction a minimum of 1 year before the study. The mean time from surgery to abdominal sensory evaluation was 42.1 months, with a range from 12 to 216 months. The average patient age at the time of testing was 51.9 years (range, 37 to 71 years). None of the patients evaluated had local or systemic diseases, such as diabetes mellitus, or neuropathies that might influence neurological testing.

Study patients were compared with 10 volunteer female controls. The average age of the controls was 32.7 years, with a range of 27 to 40 years. None of these volunteers had any previous abdominal surgery or local or systemic diseases that might have influenced neurological testing.

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Surgical Technique

All patients had pedicled TRAM flap reconstructions performed by the same surgeon (the senior author). A standard muscle-splitting surgical technique was used.[2,3] Twenty-two patients underwent unilateral and three patients underwent bilateral breast reconstruction ($n = 25$). Twenty-one single-pedicle and seven double-pedicle TRAM flaps were performed. Direct fascial repair was performed in all patients.

Evaluation

Participating patients were evaluated both subjectively and objectively between January and April of 1999. All patients were questioned and charts reviewed for history of local or systemic disease or previous abdominal surgery. Patients with these findings were excluded from the study.

Subjective Assessment

Patients were asked to indicate on a visual analog scale from 0 to 10 the degree to which the postoperative change in abdominal sensation concerned them. Zero on the scale represented no concern, and 10 indicated significant concern. This donor-site morbidity score was recorded for each patient.

Patients were also questioned regarding the presence of paralgesia or hyperaphia, and affected areas were recorded by zone.

Objective Assessment

The abdomen was specifically divided into 12 discrete zones numbered consecutively from 1 to 12 (Fig. 1). Abdominal sensation was then assessed using several techniques to evaluate distinct sensory receptors. All testing was performed by a single examiner. Each zone was tested for the following sensory modalities: (1) superficial touch, which is mediated by both large- and fast-myelinated nerve fibers and small- and slow-myelinated nerve fibers; (2) pain that is mediated through the naked terminals of small-myelinated and unmyelinated (Aδ and C) nerve fibers; (3) temperature that is also mediated by these nerve fibers; (4) vibration, perceived by pacinian corpuscles in the skin and transmitted through moderately large-myelinated nerve fibers (Aβ); and (5) constant touch/pressure that is also mediated by both large- and fast-myelinated nerve fibers and small- and slow-myelinated nerve fibers.

Each subject and control was placed in the supine position on an examining table. They were then asked to close their eyes and indicate positively their responses to the sensory modality applied. If the subject or control was unsure about feeling the given modality, the individual was asked to point to the location at which stimulus was perceived. This was used to clarify true positive responses.

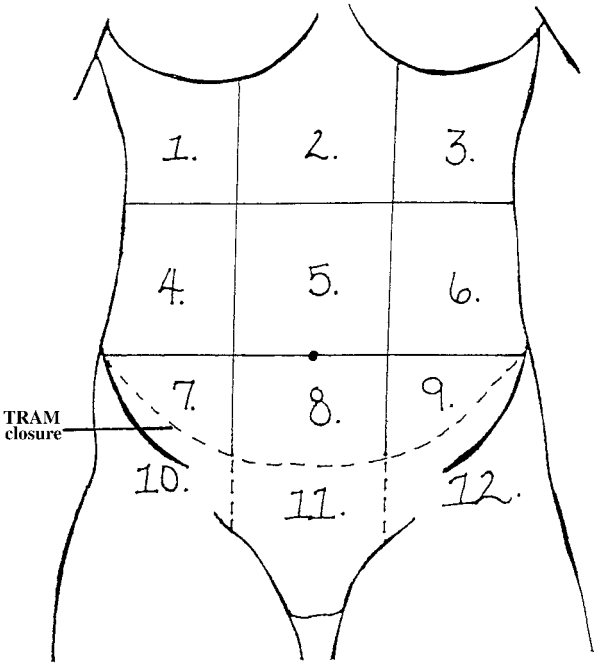

FIG. 1. Zones of the abdomen.

To test superficial touch, a cotton wisp was gently touched to the skin using light strokes. The skin was not depressed and areas with hair were avoided. Results for each zone were recorded as positive (the sensation was felt) or negative (the sensation was not felt).

A sharpened tongue blade was then used to test superficial pain. Alternating the sharp and smooth edges of the tongue blade, the skin was touched in an unpredictable pattern within each zone. A minimum of 2 seconds was allowed between each stimulus to avoid a summative effect.

Temperature was tested using a metal cylinder stored at a constant temperature of 40°F. The cylinder was rolled over a short segment of skin in each zone, and the responses were recorded again in the same manner.

Using a tuning fork of 128 Hz, each zone was assessed for vibratory sensation. Occasionally, the tuning fork was dampened before application to verify that the subject could distinguish a difference.

Fisher's exact test was used to analyze re-

sponse for all four sensory modalities. The p value was set at 0.05.

To assess the degree to which superficial touch sensibility was affected, Semmes-Weinstein monofilaments were used. Seven monofilaments with handle markings of 6.64, 6.10, 5.46, 5.07, 4.74, and 4.08 (log 10 × force in grams required to cause bowing)[4,5] were placed on the skin in each zone of the subjects. These filaments correspond to cutaneous pressure thresholds of 439, 243, 107, 65.6, 58.0, 33.1, and 29.3 g/mm^2, respectively. Pressure was applied until bowing occurred. A sustained time of greater than 5 seconds, as described by van Vliet et al.,[6] was used for each monofilament. As described, responses were recorded as positive if the filament was felt and in the proper location.

Control volunteers were also assessed using the monofilaments. Monofilaments with handle markings of 4.31, 4.08, 3.84, 3.61, 3.22, 2.83, and 2.44 were used. These correspond to cutaneous pressure thresholds of 33.1, 29.3, 19.3, 17.7, 11.1, 4.86, and 3.25 g/mm^2. The same technique, as described above, was used. Responses were recorded as above.

Student's t test was used to analyze responses for monofilament testing. The p value was set at 0.05.

Results

Subjective Assessment

The degree to which the postoperative change in abdominal sensation concerned patients was quantified using a visual analog scale from 0 to 10. Zero on the scale represented no concern, and 10 indicated significant concern. Sixteen of the 25 subjects appreciated some degree of sensibility loss. Typically, these were seen in zones 5, 7, 8, and 9, with 5 and 8 most commonly reported. When questioned about paralgesia or hyperaphia, only three subjects indicated sensations significant for comment. Two of the subjects had undergone TRAM reconstruction using the left rectus abdominis. One subject complained of hyperaphia in zones 9, 11, and 12, and the other in only zone 7. The third subject had undergone TRAM reconstruction using the right rectus muscle and complained of hyperaphia in zones 3, 10, 11, and 12.

Objective Assessment

Subjects were compared with controls for all sensory modalities. Fisher's exact test was used to analyze responses. Superficial touch was diminished significantly in zones 5 and 8, with 66.0 and 80.0 percent of patients, respectively, indicating no sensation. Superficial pain was found to be decreased significantly at zones 5 and 8, with 64 and 72.0 percent of patients, respectively, indicating no sensation. Temperature was also reduced significantly at zones 5 and 8, with 72.0 and 88.0 percent of patients, respectively, indicating no sensation. A difference in vibratory sensation was found to be statistically significant at zones 4, 5, 6, 8, and 9, with 40.0 percent, 80.0 percent, 48.0 percent, 88.0 percent, and 40.0 percent, respectively, indicating no sensation (Table I).

Subjects were also compared with controls using multiple Semmes-Weinstein monofilaments. The smallest filament felt was recorded for each zone for both subjects and controls. Subject and control results were then compared using Student's t test. No correction was made for multiple testing, and unequal variances should be noted. Significance was found in all zones at $p = 0.005$ (Table II).

The control group represents the normal cutaneous sensation of the abdomen in the young, healthy female. This control group had a mean cutaneous pressure threshold of 9.10 g/mm^2, with a range of 5.96 to 11.58 g/mm^2.

Discussion

The source of sensory innervation of the rectus abdominis muscle and the overlying abdominal skin has been studied in detail and reported by Duchateau et al.[7] According to

TABLE I

Subject Responses to All Sensory Modalities* (n = 25)

Zone	Superficial Touch	Superficial Pain	Temperature	Vibration
1	23	23	25	24
2	20	20	20	18
3	23	23	24	20
4	24	24	23	15†
5	11†	9†	7†	5†
6	22	24	22	13†
7	24	20	24	20
8	5†	7†	3†	3†
9	21	20	21	15†
10	20	23	21	22
11	17	21	19	19
12	19	21	20	21

* Numbers represent positive respondents per modality per zone.
† Significance.

TABLE II
Abdominal Sensibility Using Semmes-Weinstein Monofilaments

Zone	Subject Mean (g/mm^2)	SEM*	Control Mean (g/mm^2)	SEM*
1	38.42	3.78	8.23	2.08
2	85.62	26.78	9.19	2.32
3	50.30	16.33	10.14	2.30
4	36.76	2.75	6.59	1.58
5	244.54	39.08	5.96	1.51
6	38.72	3.76	8.07	2.23
7	45.99	5.31	9.35	2.39
8	339.15	33.56	9.67	2.31
9	67.5	17.88	9.64	2.10
10	56.21	16.58	10.96	2.47
11	87.08	26.78	9.83	2.37
12	66.84	22.50	11.58	2.27

* SEM, standard error of the mean.

that study, the anterior branches of the sixth to twelfth intercostal nerves travel with an accompanying artery in a plane between the transversus abdominis and internal oblique muscles. They then penetrate the internal oblique fascia, divide into two branches, and enter the posterior rectus sheath to provide segmental innervation. One of the branches ascends an average of 3 cm from the lateral edge of the rectus muscle to supply sensation to the skin overlying the lateral half of the rectus muscle. The other branch travels between the rectus muscle and the posterior sheath before penetrating the linea alba and supplying sensation to the skin overlying the medial half of the rectus muscle.

The anatomical course of these intercostal nerves necessitates their division, in the subcutaneous plane bilaterally to the costal margins, during the elevation of the abdominal skin flap. The ipsilateral nerves are also divided in the plane between the posterior rectus sheath and the rectus muscle as the muscle is raised from the posterior sheath. This, too, can generally not be avoided, despite the use of muscle-splitting techniques.[5]

The purpose of this study was to determine whether the gross sensibilities of superficial touch, superficial pain, temperature, and vibration were permanently affected by the TRAM flap surgery. What is apparent from our findings is that zones 5 and 8, the immediately supraumbilical and infraumbilical regions, are most affected by the surgery. The majority of all women undergoing TRAM flap breast reconstruction can be expected to lose some or all sensation in these regions.

The extent to which superficial touch was affected was examined to quantify sensibility loss. Although all zones had decreased sensibility from controls, the zones of the midline (zones 5 and 8) seem to have the greatest change. This is in keeping with the technique used to develop the TRAM flap and its pedicle.

To date, there have been no formal quantitative studies performed to define the range of normal abdominal sensation. The only attempt to define normal sensation in the peer review literature involved a sample of eight young, female volunteers who were tested using Semmes-Weinstein monofilaments in the infraumbilical region.[8] This control group had a mean cutaneous pressure threshold of 29.2 g/mm^2. Our study demonstrates that the mean cutaneous pressure threshold in healthy, young women is considerably lower, at 9.10 g/mm^2, than previously found.

This study has clearly demonstrated that there is a significant and persistent reduction in abdominal sensibility following TRAM flap surgery. This is in contrast to the long-held belief that this sensory deficit would continue to improve and perhaps resolve with the passage of time. The abdominal complications associated with TRAM flap breast reconstruction include abdominal incompetence, frank herniation, skin necrosis of the lower abdominal incision area, and, as outlined in this study, permanent loss of sensation to part of the abdomen. Because the TRAM flap provides the opportunity to create a natural, autogenous breast that simulates the opposite breast, it is reasonable to accept these morbidities as a small price for a reconstructed breast that is unsurpassed in aesthetic beauty.

The sensory deficit involves all the modalities, superficial touch, superficial pain, temperature, and vibration. The distribution of the deficits is consistent; it involves, in particular, the midline supraumbilical and infraumbilical regions of the abdomen. This information can be used in advising patients preoperatively of anticipated sensory changes.

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