Areola-Nipple Perception Threshold to Faradic Electricity: A New Measure of Sensibility of the Breasts

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Abstract

Background We describe a new method to study the sensibility of the nipple-areola complex of the breast with faradic electricity delivered through an electromyographic device used to monitor peripheral nerve conduction.

Methods The objective results of faradic pulses (2–50 mA per pulse) delivered to the nipple-areola complex of the breast through a Nihon-Kohden II machine (Evoked potential/Electromyographs, Nihon-Kohden Co., Japan) were evaluated in normal volunteers to get a basal measure that was defined by the patient as “a soft electric discharge.” The measures were recorded and their output discharges averaged (at least 5 to each complex).

Results Twenty-eight volunteers with normal breasts, 28 patients with breast hypertrophy before and after breast reduction, and 28 patients before and after breast augmentation were studied. The faradic pulses were perceived from 1.5 to 3.5 mA in the areola and from 3 to 5.5 mA in the nipple in the control group and from 4.5 to 7.0 mA in the areola and from 6.5 to 9.5 mA in the nipple in the breast hypertrophy group with no significant changes before and after surgery. In the breast augmentation group the faradic pulses were very similar to the volunteers that had normal breasts, but 13 months after breast augmentation with silicone gel prosthesis, a difference was found because all the patients had a higher threshold and three cases had lost sensibility of the nipple-areola complex.

Conclusion In normal breasts the areola had a lower threshold for faradic pulses compared to the nipple. Hypertrophic breasts had a higher threshold to the faradic stimulation than normal subjects in the pre- and postoperative period. Hypoplastic breasts before breast augmentation had a perception threshold similar to that of the normal volunteers but after breast augmentation this perception was much higher.

Keywords Breast sensibility · Faradic stimulation · Nipple-areola thresholds · Faradic pulses

The sensibility of the areola-nipple complex (NAC), i.e., tact, pressure, vibration, discrimination between two points, temperature as hot and cold, and the erogenous sensation, is a subjective condition that is difficult to standardize [1–3]. The Semmes-Weinstein monofilaments (Touch-Test™ Sensory Evaluators, Hospeq, Inc., Miami, FL) use segments of flexible nylon of variable diameter to evaluate cutaneous sensibility of the breast as pressure thresholds. This method has drawbacks because the stimulus produced is variable and provides an estimate of the range of cutaneous pressure thresholds and not a true measurement of that threshold; the values obtained are logarithms that have to be converted to force or pressure values so there is no way to ensure the reliability or accuracy of the measurements. Also, frequent use may alter the calibration of or rupture the monofilaments [4].

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The vibrometer [5] test studies vibratory thresholds with a Bio-thesiometer (Bio-medical Instrument Co., Newbury,OH). The instrument is designed to measure the threshold of appreciation of vibration in human subjects. It works as an "electrical tuning fork" whose amplitude may be set to any predetermined level or may be gradually increased until the threshold of vibratory sensation is reached. Conversely, the amplitude may be lowered until the vibration is no longer discernible. In all cases the amplitude may be determined at any given level with a high degree of accuracy. It also has limitations because it generates a wave that travels to the nipple and the areola stimulating both at the same time. The instrument is calibrated in the air, and values provided are dependent on the pressure applied to the probe.

The computer-assisted neurosensory test uses a computerized pressure-testing device (Pressure-Specified Sensory Device, Sensory Management Systems, LLC, Baltimore, MD) that can assess nerve function by quantifying the thresholds of pressure detected with light, static, and moving touch. It consists of one or two blunt probes and sensitive transducers to measure and record the perception thresholds of pressure on the surface of the breast in grams per square millimeter. It is a noninvasive method that provides a continuous measurement of cutaneous pressure. This allows for static, moving one-point and static, moving two-point discrimination. Recalibration is performed for each new test ensuring the reliability and accuracy of data acquired [6, 7].

The use of dermatomal somatosensory evoked potentials as a new method to evaluate breast sensibility is difficult to do and its interpretation needs a neurophysiology expert [8].

The purpose of this study is to describe a new method to study the sensibility of the nipple-areola complex of the breast with faradic electricity delivered through a standard electromyographic device used to monitor peripheral nerve conduction.

Materials and Methods

Faradic pulses are delivered to the NAC through a Nihon-Kohden II machine (Fig. 1) that gives 2–50 mA per pulse. To obtain objective measures of sensation of the NAC we were guided by a neurosurgeon. A total of 28 female volunteers with normal breasts (A and B cups and with external nipple distances from 19 to 23 cm) were enrolled in the study. Eight did not have children and 20 had had children and previous lactation. Faradic electricity was delivered in two ways: with two probes (one in front of the other on top of the areola) or with a fixed sensor (Figs. 2–5). To get a basal measure that was defined by the patients as "a soft electric discharge to the NAC," 1.5–5.5 mA of faradic stimulation was needed. The measures were recorded and their output discharges (at least 5 to each NAC) were averaged. Another 28 candidates for breast reduction were studied pre- and postoperatively (after 13 months). All had D cups and the reduction technique used was the Hall-Findlay medial pedicle vertical reduction mammaplasty. Finally, 28 candidates for breast augmentation using the Style 120 McGhan texturized silicone implants, the caudal-periareolar and retromuscular approach used in all, were studied pre- and postoperatively after 13 months of the implantation.

Fig. 1 Nihon-Kohden II machine (Evoked potential/Electromyographs, Nihon-Kohden Co., Japan), generating 2–50 mA per pulse of faradic continuous electric current (square wave pattern)

Results

The median and range of the faradic thresholds in normal, hypertrophic, and hypoplastic breasts are summarized in Table 1. In normal female subjects the faradic pulses were perceived from 1.5 to 3.5 mA in the areola and from 3 to 5.5 mA in the nipple. Nipples required more faradic

Fig. 2 Faradic electricity was delivered to the NAC with two probes placed horizontally

Fig. 3 Faradic electricity was delivered to the NAC with two probes placed vertically

Fig. 4 Fixed probe

Fig. 5 Faradic electricity was delivered to the NAC with a fixed probe

stimulation than areolas in normal, hypertrophic, and hypoplastic breasts ($p < 0.001$). In females with hypertrophic breasts, the faradic pulses were perceived from 4.5 to 7.0 mA in the areola and from 6.5 to 9.5 mA in the nipple. In this group of patients, there were no differences in pre- and postoperative perceptions ($p > 0.05$) but the thresholds were significantly higher when compared to normal breasts. In females with hypoplastic breasts, the preoperative faradic pulses showed no differences with normal breasts. After breast augmentation, higher stimulation levels were found and were significantly higher than normal breasts. Postoperative levels of hypoplastic breasts were similar to those of hypertrophic breasts.

Discussion

The nipple and the areola are distinct structures with different anatomy, physiology, and sensitivity [2, 3, 9–12]. Confusion of terminology could affect the outcome of clinical studies.

The NAC has dual innervation that comes from the medial and lateral cutaneous branches of the third through sixth intercostal nerves. The dominant nerve supply comes from the fourth intercostal nerve that, after penetrating the serratus anterior muscle at the midaxillary line, travels along the serratus fascia to the lateral border of the pectoralis muscle. A lateral cutaneous branch and an anterior cutaneous branch innervate the nipple-areola complex inferolaterally and medially [12]. Perception of faradic electricity could be considered a neurologic conduction test of the fourth intercostal nerve that innervates the nipple-areola complex [9–13]. Previous studies include two-point discrimination, vibratory thresholds, light touch, cotton-wool, pin-prick, pain perception to electrical currents, and the Semmes-Weinstein

Table 1 Faradic thresholds for the different study groups

	Normal breasts	Hypertrophic breast		Hypoplastic breasts		Not significant p value[b]
	A	Preoperative B	Postoperative C	Preoperative D	Postoperative E	
Right nipple[a]	4 (2.5–8)	7.8 (5.5–8)	8 (7–8.5)	3.5 (2.5–4.5)	12 (8–14)	A vs. D B vs. C C vs. E
Left nipple[a]	4 (3–4.5)	6.5 (4–9.5)	6.5 (4–9)	4 (3.5–4.5)	10.3 (8.5–14)	A vs. D B vs. C
Right areola[a]	3 (1.5–3.5)	6.5 (4.5–7)	6.5 (5.5–6.5)	3 (2.5–4)	9 (6.5–12.5)	A vs. D B vs. C B vs. E
Left areola[a]	2.5 (2–3)	5 (3–7)	4.5 (2.5–7)	3.5 (3–4)	10 (7–14.5)	B vs. C B vs. D C vs. D

[a] Miliamperes expressed in median and range

[b] Kruskall-Wallis test with Dunn's multiple comparison post-test were used for statistical analysis and only the combinations that demonstrated no differences ($p > 0.05$) are shown

monofilament test, which has been considered the "gold-standard" of sensibility studies of the breast. A review of the most recent literature on normal breast sensibility using Semmes-Weinstein nylon monofilaments yields data varying by a magnitude that exceeds tenfold [1, 3, 4]. For these reasons the pressure-specified sensory device, a computer-assisted force transducer that measures static and moving one- and two-point discrimination, has demonstrated a tenfold difference in measurable sensory thresholds in normal patients from preexisting data from Semmes-Weinstein monofilaments, so this technology should be considered the new "gold standard" of sensibility breast studies [6].

The present study represents the first quantitative sensibility analysis of the NAC (and not the overlying skin of the mammary gland) done with faradic electricity. Electric currents can be continuous or alternating (as in domestic use; it has a sinusoidal curve and "never stops" until "unplugged"). For this study we used a continuous electric current, which has a square curve and two forms, galvanic and faradic, the difference being that faradic electricity has a duration of less than 1 ms. Our patients' perceptive data to faradic electricity were strictly correlated with the quantitative data (Table 1).

In normal volunteers the sensitivity at the nipple was greater than at the areola after the faradic electricity test. Although the nerve density is higher in the nipple, this does not directly explain why a lower electrical threshold is more readily felt in the nipple than the areola. Our study confirmed the decreased sensibility seen in other studies with macromastia [6, 14–25], but sensation is not necessarily made worse by Hall-Findlay medial-pedicle reduction mammaplasty, as originally proposed by Courtiss and Goldwyn [26].

For this study, in females with hypoplastic breasts, the faradic pulses were very similar to the normal volunteers with normal breasts, but 13 months after breast augmentation with silicone gel prostheses they had a higher threshold to faradic stimulation of the NAC. Previous studies that evaluated nipple sensation after breast augmentation [27–29] found a 15–49% change in nipple sensation. Courtiss and Goldwyn [26], using light finger touch and evaluation of pain using the Vitapulp (Pelton and Crane, Charlotte, NC), demonstrated that 15% of patients had decreased sensation in the nipple-areola complex (before and after breast plastic surgery) at 2 years, and the larger the implants, the greater the sensory loss. The implants in their study were subglandular, whereas the implants in our study were submuscular. Whether this difference in implant location explains the difference in sensibility noted in the two studies is unclear.

Finally, the perception of sensation in the areola and that in the nipple are different, and the cause for this perception difference could not be explained in our study. Other authors have tried to explain the differences as a pure reflection of nerve fiber density (higher in the nipple compared to the areola) or traction injury in macromastia or after the use of large silicone prostheses for breast enhancement [30].

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