ELSEVIER

EVALUATION OF FEMALE EXTERNAL GENITALIA SENSITIVITY TO PRESSURE/TOUCH: A PRELIMINARY PROSPECTIVE STUDY USING SEMMES-WEINSTEIN MONOFILAMENTS

LAURI J. ROMANZI, ASNAT GROUTZ, FARIHA FEROZ, AND JERRY G. BLAIVAS

ABSTRACT

Objectives. To assess the use of pressure aesthesiometers (Semmes-Weinstein monofilaments) in the evaluation of female external genitalia. The pressure aesthesiometers are widely used to assess the pressure/touch perceptions of the hand, face, and breast dermatomes.

Methods. Thirty-two consecutive neurologically intact women (mean age 48.7 ± 13.8 years) and 5 neurologically impaired women referred for a routine gynecologic examination were prospectively enrolled. The monofilaments were applied to the S2-S5 vulvar dermatomes using specific anatomic landmarks. Test-retest reliability studies were performed at the same clinical session. A comparison was made between premenopausal (n = 17) and postmenopausal (n = 15) women; hypoestrogenic (n = 9) and normoestrogenic (n = 23) women; postmenopausal women with (n = 6) and without (n = 9) estrogen replacement therapy; women with normal (n = 18) and abnormal (n = 14) sexual function; and neurologically impaired (n = 5) and neurologically intact (n = 5) women, matched by age, parity, and estrogen status.

Results. A clear association was found between reduced vulvar sensitivity to pressure/touch and estrogen deficiency, sexual dysfunction, and neurologic impairment. Postmenopausal women had significantly reduced sensitivity to pressure/touch compared with premenopausal women. Similar decreased sensitivity was found in hypoestrogenic compared with normoestrogenic women, with significantly reduced sensitivity in postmenopausal women not using estrogen replacement therapy. Women with sexual dysfunction and those with neurologic impairment had significantly reduced vulvar sensitivity to pressure/touch. No correlation was found between the sensitivity to pressure/touch and either levator ani muscle bulk or the levator contraction score, but significant differences were found between women with and without vulvovaginal atrophy at the time of the examination. Test-retest analysis confirmed the reliability of the monofilaments in testing vulvar sensation.

Conclusions. The Semmes-Weinstein monofilaments may be used as a valid and reliable diagnostic tool in the evaluation of vulvar sensitivity to pressure/touch. Additional studies with larger series are needed to establish the role of this clinical tool in the evaluation of various treatment outcomes. UROLOGY **57:** 1145–1150, 2001. © 2001, Elsevier Science Inc.

Normal skin sensation requires intact function of neural, vascular, endocrine, and psychogenic mechanisms. Several diagnostic tools are traditionally used to assess skin sensation, including temperature, vibratory, sharp/dull, and single-point and two-point discrimination. Von Frey[1] was the first to use horse hair, attached to wax candles, to study single-point skin sensitivity to pressure/touch. This method is based on the principle that a fiber, pressed against the skin until it bends, produces a constant reproducible application of force. The bending force is proportional to the fiber diameter and inversely proportional to its length. Semmes *et al.*[2] and Weinstein[3] further modified Von Frey's invention by using 20 nylon monofilaments (Semmes-Weinstein pressure aesthesiometers; Stoelting, Wood Dale, Ill), all of equal length but of varying diameters. The diameters of the fil-

Financial support to A. Groutz was provided by the Institute for Bladder and Prostate Research.

From the Departments of Obstetrics and Gynecology and Urology, Weill Medical College, Cornell University, New York, New York

Reprint requests: Lauri J. Romanzi, M.D., 962 Park Avenue, New York, NY 10028

Submitted: December 7, 2000, accepted (with revisions): January 29, 2001

0090-4295/01/$20.00
PII S0090-4295(01)00964-5

aments are labeled to provide a logarithmic scale of applied force. The readings are then converted into milli-Newtons (mN). These filaments are considered an acceptable standard clinical tool to assess sensory deficits in pathologic processes such as carpal tunnel syndrome.[4] Similarly, these monofilaments are used to assess nerve regeneration after head or breast surgery.[5–12] They are inexpensive, convenient, easy to use, and associated with relatively high patient compliance.

Data regarding the skin sensitivity of the vulva are scarce. Common pathologic processes such as hormone deficit, local inflammation, and surgical intervention may all impair vulvar sensation. Furthermore, vulvar sensation is a key component in normal sexual function. Currently, however, no standardized widely accepted objective tools are available to assess female genital sensation.[13,14] The aim of the present study was to assess the validity, as well as the test-retest reliability, of the Semmes-Weinstein monofilaments in the evaluation of vulvar sensitivity to pressure/touch.

MATERIAL AND METHODS

Patients

Thirty-seven consecutive women (32 neurologically intact and 5 neurologically impaired), referred for a routine gynecologic examination, were prospectively enrolled. The exclusion criteria included age younger than 18 years, pregnancy, acute vulvovaginitis, vulvar dermatitis, acute cystitis, moderate or severe urogenital prolapse, active menses at the time of the examination, tampon or pad used the day of the examination, recent vaginal surgery, and insulin-dependent diabetes mellitus. All women were evaluated by a single examiner (L.J.R.).

Investigations

All patients underwent a thorough gynecologic evaluation composed of a detailed medical, neurologic, gynecologic, and obstetric history and a full pelvic examination, including assessment of the urogenital estrogen status, pelvic floor support, levator ani muscle bulk, and levator contraction scale. The technique, validity, and reliability of the levator contraction scale used in this study have been published elsewhere.[15]

The neurologic status of the patients was determined by history, physical examination, and additional imaging studies, such as magnetic resonance imaging, when the results of the clinical evaluation raised any suspicion of neurologic findings.

Sexual function was assessed by interviewing the patients regarding sexual activity, desire, arousal, orgasm, and dyspareunia. Each patient was asked whether she had experienced any changes in libido, changes in genital response to stimulation, changes in time to and intensity of orgasm, or any pain with intercourse that seemed to affect desire, arousal, and/or orgasm. With the exception of the dyspareunia question, these questions were derived from a short, validated, sexual function questionnaire.[16] For statistical analysis, we defined sexual dysfunction as a self-reported significant decrease in libido, response to genital stimulation, increase in time to orgasm, decrease in intensity of orgasm, or dyspareunia.

Before examining the vulvar sensitivity to pressure/touch, each participant was shown the filaments and a demonstration was carried out on the hand to familiarize each patient with the light sensation of pressure/touch produced by the filaments.

Semmes-Weinstein Monofilaments Technique

The sensitivity of the S2-S5 vulvar dermatomes to pressure/touch was investigated in the dorsal lithotomy position before any further pelvic examination. The patient was told where she would feel the sensation but was not told when the filaments were applied. The examiner was not visible to the participant. Filaments in varying diameters were applied consecutively up to the threshold of perception. The patient was requested to report the filament to which she perceived a definite sensation of light pressure or pressure/touch.

The filaments were applied sequentially to fixed anatomic landmarks of the S2-S5 vulvar dermatomes: clitoral glans (S2), right and left inner aspects of the labia minora (S3), right and left aspects of the perineal body (S4), and the 12-o'clock position at the anal verge (S5). Test-retest reliability was assessed by repeating the study 5 minutes after completion of the first evaluation.

The diameters of the filaments were selected and labeled to provide a logarithmic scale of applied force. To facilitate statistical analysis, the logarithmic handle readings were converted into ordinal data using the corresponding values of force in grams generated provided by the manufacturer and then converting the force in grams to milli-Newtons. The conversion from force in grams to milli-Newtons was done to maintain consistency with other studies using Semmes-Weinstein monofilaments, the overwhelming majority of which report data in milli-Newtons.

Main Outcome Measures

The two readings (test-retest) for each of the six sites applied were averaged for every participant. Two more scores were created for the labia (S3) and perineum (S4), for which the readings were undertaken bilaterally, by averaging the total of the four readings per dermatome (bilateral labia score and bilateral perineum score). Finally, each patient had a total vulvar score created by averaging all readings (total score). The data were analyzed for each of the six anatomic sites tested, plus the two bilateral scores and the total score.

The results of the 32 neurologically intact women were first analyzed separately and then compared between the premenopausal ($n = 17$) and postmenopausal ($n = 15$) women; postmenopausal women with ($n = 6$) and without ($n = 9$) estrogen replacement therapy (ERT); and women with normal sexual function ($n = 18$) and those with sexual dysfunction ($n = 14$). Additional analysis was performed according to the presumed estrogenic status of the women. For analysis, we considered premenopausal women and postmenopausal women using ERT to be normoestrogenic ($n = 23$), and postmenopausal women not using ERT were considered hypoestrogenic ($n = 9$). We also correlated the genital sensation results with the findings at the physical examination (ie, levator ani muscle bulk, levator contraction score, and vulvovaginal atrophy).

An additional comparison was carried out between the 5 neurologically impaired patients with multiple sclerosis and 5 neurologically intact women, matched by age, parity, and estrogen status.

Statistical Analysis

A valid test measures what it intends to measure. A reliable test requires consistency of the results. Test-retest reliability is confirmed when a high level of agreement is found between short-term replicate observations within a specific interval, when the stability of the condition would be expected. The alpha reliability analysis scale was used to assess the test-retest

TABLE I. *Patient characteristics (n = 32)*

Age (yr)	48.7 ± 13.8
Premenopausal	38.4 ± 6.4
Postmenopausal with ERT	58.2 ± 11.9
Postmenopausal without ERT	62.1 ± 8.5
Race (n)	
White	29 (91)
Black	1 (3)
Hispanic	2 (6)
Menstrual status (n)	
Premenopausal	17 (53)
Postmenopausal	15 (47)
With ERT	6 (40)
Without ERT	9 (60)
Urinary incontinence (n)	7 (21)
Previous vaginal surgery (n)	2 (6)
Previous abdominal pelvic surgery (n)	6 (18)

KEY: ERT = estrogen replacement therapy.
Data presented as the mean ± SD for age; numbers in parentheses are percentages.

TABLE II. *Semmes-Weinstein monofilaments readings in neurologically intact women (n = 32)*

Vulvar Dermatome	Mean Score (mN)
Clitoral glans (S2)	2.10 ± 2.97
Right labum minus (S3)	1.73 ± 3.50
Left labum minus (S3)	1.69 ± 2.42
Bilateral labia (S3)	1.71 ± 2.43
Right perineum (S4)	2.15 ± 4.38
Left perineum (S4)	2.10 ± 4.43
Bilateral perineum (S4)	2.13 ± 4.39
Anal verge (S5)	1.74 ± 2.95
Total vulvar score	1.92 ± 2.75

Data presented as the mean ± SD.

reliability of the results. The Mann-Whitney and Kruskal-Wallis tests were used to compare different subgroups of the study population, and the Spearman correlation coefficient was used to assess the correlation between the genital sensation findings and the physical examination findings. *P* values of less than 0.05 were considered significant. The data are presented as the mean ± SD or the percentage according to the variables.

RESULTS

The patient characteristics are presented in Table I. The mean age of the patients was 48.7 ± 13.8 years. The mean age of the postmenopausal women using ERT was not significantly different from the postmenopausal women not using ERT (58.2 ± 11.9 versus 62.1 ± 8.5 years, respectively; $P = 0.466$).

The results for each of the genital dermatomes of the 32 neurologically intact women are presented in Table II. The test-retest analysis revealed that the Semmes-Weinstein monofilaments should be considered a reliable tool to assess female genital sensation (correlation coefficient 0.78).

Postmenopausal women demonstrated significantly reduced sensitivity in the clitoral, labial, and total scores compared with premenopausal women (Table III). Similar decreases in cutaneous sensitivity were found in all dermatomes and for the total scores in hypoestrogenic women compared with their normoestrogenic counterparts (Table IV). When comparing filament readings in postmenopausal women with and without ERT, statistically significant differences were found only in the S5 dermatomes and the total scores. However, a comparison of premenopausal women and postmenopausal women using and not using ERT demonstrated statistically significant differences among the three groups, with significantly reduced sensitivity in the postmenopausal women not using ERT.

Women with sexual dysfunction had significantly reduced sensitivity in all individual dermatomes and reduced sensitivity in the total scores compared with women without sexual dysfunction (Table V).

No correlation was found between the sensitivity to the Semmes-Weinstein monofilaments and either levator ani muscle bulk or levator contraction score, but significant differences were found between women with and without vulvovaginal atrophy at time of the examination ($P = 0.0001$).

When the group of 5 neurologically impaired (multiple sclerosis) patients were compared with 5 neurologically intact controls, matched by age, parity, and estrogen status, the total scores of the neurologically impaired women were significantly higher (ie, sensitivity lower) than their neurologically intact counterparts (4.54 versus 0.61 mN, respectively; $P = 0.016$).

COMMENT

The results of the present study suggest that the Semmes-Weinstein monofilaments may be used as a valid and reliable diagnostic tool in the evaluation of vulvar sensitivity to pressure/touch. This may have additional clinical implications regarding our understanding of the pathophysiologic processes, as well as in evaluating treatment outcomes.

Cutaneous sensitivity to pressure/touch involves perception by way of pressure-sensitive Merkel discs with afferent transmission along group A beta fibers to the pudendal/sacral nerve roots. The evaluation of the postoperative recovery of Merkel disc function is an important part of documenting nerve regeneration after hand and face reconstructive procedures. The established methods of evaluating cutaneous sensation include single and two-

TABLE III. *Correlation of menstrual status to Semmes-Weinstein monofilaments sensitivity*

Vulvar Dermatome	Mean Score (mN) Premenopausal (n = 17)	Mean Score (mN) Postmenopausal (n = 15)	*P* Value*
Clitoral glans (S2)	0.95	3.40	0.039
Right labum minus (S3)	0.86	2.72	0.040
Left labum minus (S3)	0.84	2.66	0.021
Bilateral labia (S3)	0.85	2.69	0.017
Right perineum (S4)	0.57	3.94	0.144
Left perineum (S4)	0.45	3.97	0.115
Bilateral perineum (S4)	0.51	3.96	0.145
Anal verge (S5)	1.30	2.23	0.153
Total vulvar score	0.83	3.15	0.003

* *Mann-Whitney test.*

TABLE IV. *Correlation of estrogen status to Semmes-Weinstein monofilaments sensitivity*

Vulvar Dermatome	Mean Score (mN) Hypoestrogenic (n = 9)	Mean Score (mN) Normoestrogenic (n = 23)	*P* Value*
Clitoral glans (S2)	3.67	1.48	0.014
Right labum minus (S3)	3.70	0.96	0.033
Left labum minus (S3)	3.43	1.01	0.043
Bilateral labia (S3)	3.57	0.99	0.025
Right perineum (S4)	6.07	0.62	0.015
Left perineum (S4)	6.17	0.51	0.014
Bilateral perineum (S4)	6.12	0.56	0.017
Anal verge (S5)	3.26	1.15	0.004
Total vulvar score	4.38	0.95	0.001

* *Mann-Whitney test.*

TABLE V. *Correlation of sexual function to Semmes-Weinstein monofilaments sensitivity*

Vulvar Dermatome	Mean Score (mN) Normal Sexual Function (n = 18)	Mean Score (mN) Sexual Dysfunction (n = 14)	*P* Value*
Clitoral glans (S2)	1.49	2.87	0.034
Right labum minus (S3)	1.76	1.70	0.010
Left labum minus (S3)	0.94	2.66	0.039
Bilateral labia (S3)	1.35	2.18	0.022
Right perineum (S4)	1.02	3.60	0.007
Left perineum (S4)	1.01	3.50	0.008
Bilateral perineum (S4)	1.02	3.55	0.004
Anal verge	1.65	1.85	0.017
Total vulvar score	1.31	2.70	0.001

* *Mann-Whitney test.*

point discrimination, sweat testing, vibratory stimulus, moving pressure/touch, and constant pressure/touch. Recent work by Vardi *et al.*[14] found the distribution of temperature data to be significantly wider than that of vibratory sensation. Light touch and vibration are mediated by the large, myelinated group A beta fibers, and temperature sensation is mediated by small fibers; the relevance to female sexual dysfunction may be less significant than the vibratory data.[14]

Von Frey[1] was the first to use horse hairs of varying thickness to study normal sensory neurophys-

iology. Semmes *et al.*[2] and Weinstein[3] modified the Von Frey method by using nylon monofilaments of fixed length and increasing diameters mounted in Lucite handles. These filaments provide a range of progressive pressures to evaluate cutaneous sensitivity to pressure/touch. The use of this tool is widespread among plastic and other reconstructive surgical specialties. The validity, as well as the inter-tester and intra-tester reliability, of this diagnostic tool has been demonstrated in evaluating pressure/touch sensitivity of the hand, face, and breast dermatomes.[17–19] The monofilaments have been used to document minimal to no change in nipple-areola sensitivity after reduction mammaplasty and a decrease in nipple-areola sensitivity associated with increasing breast size and breast ptosis.[8,10] Similarly, Temple and Hurst[11] demonstrated a significant improvement in breast sensibility after reduction mammaplasty, contrary to the popular belief that hypesthesia is the expected outcome after breast reduction.

In the present study, we assessed the use of Semmes-Weinstein monofilaments in the evaluation of vulvar sensitivity to pressure/touch. Our data confirm the validity and test-retest reliability of this simple clinical tool when applied to vulvar dermatomes. To the best of our knowledge, only one previously published study made use of this diagnostic tool with regard to female external genitalia. Foster *et al.*[20] studied 39 postmenopausal, hypoestrogenic women referred for evaluation of mixed lower urinary tract symptoms. In their study, the patients were placed in four masked treatment arms of topical estradiol cream, pelvic muscle biofeedback, and/or placebo. Topical estradiol cream was found to improve the sensitivity of the vulva to pressure/touch compared with placebo cream. The maximum intravaginal pressures during circumvaginal contraction did not differ between the estrogen and placebo groups. Similarly, Fantl *et al.*[21] demonstrated a significantly higher rate of positive bulbocavernosus reflex in postmenopausal women using estrogen compared with a group of hypoestrogenic volunteers. A significant increase in the sensory activity of the perineum has been also documented in rodents treated with estrogen.[22] Our results confirm these findings. A clear effect of estrogen on vulvar sensibility was demonstrated in our study, with menopausal status, non-use of ERT, and vulvovaginal atrophy all associated with decreased vulvar sensibility to pressure/touch. However, other studies have suggested a decreasing gradient of estrogen receptors from the vagina to the external genitalia, postulating a limited role for local estrogen therapy in the vulva.[23,24] In our series, a clear correlation was found of vulvar sensitivity to the presence or absence of vulvar atrophy, an estrogen-mediated response, but no correlation was found to pelvic muscle bulk or the pelvic muscle contraction score, which reflect motor function of the pudendal nerve. Although receptor density in the vulva may be relatively lower than the upper genital tract, the effect of estrogen in the most distal aspects of the lower genital tract is profound and includes a significant impact on sensory function.

The results of our study also suggest an association between sexual function and vulvar sensitivity to pressure/touch. Women with sexual dysfunction had significantly reduced sensitivity in all vulvar dermatomes compared with women with normal sexual function. However, owing to the small sample size and the lack of a thorough evaluation of the sexual function, these preliminary findings should be further investigated. Similarly, a significant association was found between the neurologic status and vulvar sensitivity to pressure/touch; however, larger series are needed to confirm these preliminary results.

The effect of pelvic reconstructive surgery on vulvovaginal sensibility is not known. A recent study suggested that both sexual function and satisfaction are improved or do not change in most women after surgery for prolapse and/or urinary incontinence.[25] In our series, the participants with a history of pelvic surgery were too few to draw a meaningful conclusion. Our follow-up study will assess sensibility testing both before and after surgery in women undergoing prolapse and incontinence operations.

CONCLUSIONS

The results of our study suggest that the Semmes-Weinstein monofilaments may be used as a valid and reliable diagnostic tool in the evaluation of vulvar sensitivity to pressure/touch. A clear association was found between reduced vulvar sensitivity to pressure/touch and estrogen deficiency, sexual dysfunction, and neurologic impairment. Additional studies with larger series are needed to establish the role of this clinical tool in the evaluation of various treatment outcomes and to establish normal values for each dermatome.

REFERENCES

1. Von Frey M: Verspatet Schmerzempfindungen. Z Gesamte Neurol Psychiat **79:** 324–333, 1922.

2. Semmes J, Weinstein S, Ghent L, *et al: Somatosensory Changes After Penetrating Brain Wounds in Man.* Cambridge, Harvard University Press, 1960, pp 4–11, 60, 62.

3. Weinstein S: Tactile sensitivity of the phalanges. Percept Mot Skills **14:** 351–354, 1962.

4. Mielke K, Novak C, Mackinnin S, *et al:* Hand sensibility measures used by therapists. Ann Plast Surg **36:** 292–296, 1996.

5. Terzis J, Vincent M, Wilkins L, *et al:* Breast sensibility:

a neurophysiological appraisal in the normal breast. Ann Plast Surg **19:** 318–322, 1987.

6. Posnick J, Zimbler A, and Grossman J: Normal cutaneous sensibility of the face. Plast Reconst Surg **86:** 429–432, 1990.

7. Dellon E, Mourey R, and Dellon A: Human pressure perception values for constant and moving one- and two-point discrimination. Plast Reconstr Surg **90:** 112–117, 1992.

8. Gonzales F, Brown F, Gold M, *et al:* Preoperative and postoperative nipple-areola sensibility in patients undergoing reduction mammaplasty. Plast Reconstr Surg **92:** 809–814, 1993.

9. Costas P, Heatley G, and Seckel B: Normal sensation of the human face and neck. Plast Reconstr Surg **93:** 1141–1145, 1994.

10. Tairych G, Kuzbari R, Rigel S, *et al:* Normal cutaneous sensibility of the breast. Plast Reconstr Surg **102:** 701–704, 1998.

11. Temple C, and Hurst L: Reduction mammaplasty improves breast sensibility. Plast Reconstr Surg **104:** 72–76, 1999.

12. Voerman V, van Egmond J, and Crul B: Normal values for sensory thresholds in the cervical dermatomes. Am J Phys Med Rehab **78:** 24–29, 1999.

13. Berman JR, Berman LA, Werbin TJ, *et al:* Clinical evaluation of female sexual function: effects of age and estrogen status on subjective and physiologic sexual responses. Int J Impot Res **1:** S31–S38, 1999.

14. Vardi Y, Gruenwald I, Sprecher E, *et al:* Normative values for female genital sensation. Urology **56:** 1035–1040, 2000.

15. Romanzi L, Polaneczky M, and Glazer H: Simple test of pelvic muscle contraction during pelvic examination: correlation to surface electromyography. Neurourol Urodyn **18:** 603–612, 1999.

16. Rhodes JC, Kjerulff KH, Langeneberg PG, *et al:* Hysterectomy and sexual functioning. JAMA **282:** 1934–1941, 1999.

17. Hage J, van der Steen L, and de Groot P: Difference in sensibility between the dominant and nondominant index finger as tested using the Semmes-Weinstein monofilaments pressure aesthesiometer. J Hand Surg **20A:** 227–229, 1995.

18. Novak C, Patterson M, and Mackinnin S: Evaluation of hand sensibility with single and double latex gloves. Plast Reconstr Surg **103:** 128–131, 1999.

19. Bell-Krotoski J, and Tomancik E: The repeatability of testing with Semmes-Weinstein monofilaments. J Hand Surg **12A:** 155–161, 1987.

20. Foster DC, Palmer M, and Marks J: Effect of vulvovaginal estrogen on sensorimotor response of the lower genital tract: a randomized controlled trial. Obstet Gynecol **94:** 232–237, 1999.

21. Fantl JA, Wyman JF, Anderson RL, *et al:* Postmenopausal urinary incontinence: comparison between non-estrogen-supplemented and estrogen-supplemented women. Obstet Gynecol **71:** 823–825, 1988.

22. Komisaruk B, and Adler N: Genital sensory field: enlargement by estrogen treatment in female rats. Science **173:** 1295–1298, 1972.

23. MacLean A, Nicol L, and Hidgins M: Immunohistochemical localization of estrogen receptors in the vulva and vagina. J Reprod Med **35:** 1015–1016, 1990.

24. Hodgins M, Spike R, Mackle R, *et al:* An immunohistochemical study of androgen, oestrogen and progesterone receptors in the vulva and vagina. Br J Obstet Gynaecol **105:** 216–222, 1998.

25. Weber AM, Walters MD, and Piedmonte MR: Sexual function and vaginal anatomy in women before and after surgery for pelvic organ prolapse and urinary incontinence. Am J Obstet Gynecol **182:** 1610–1615, 2000.