Pelvic floor symptoms after gynaecological surgery
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Chapter 7

A new method to measure vaginal sensibility

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Abstract

Introduction: Vaginal surgery may affect sexual function both positively and negatively. Possibly, negative consequences of surgical interventions on sexuality may be caused by reduced sensibility of the vaginal wall.

Aims: To develop a new method to measure vaginal sensibility.

Methods: We developed a technique to measure the sensibility of the vaginal wall consisting of a St Marks electrode on a gloved index finger, with a stimulating electrode mounted at the tip. Measurements were performed in four different target areas (caudal and cranial, posterior and anterior) by two independent female researchers in a random order. Subjects were 12 healthy women.

Results: The intra-observer reproducibility of both researchers was almost perfect (pearson’s-rho correlation coefficient 0.77-0.96 p < 0.001). The inter-observer reproducibility was moderate (pearson’s-rho correlation coefficient 0.39-0.49). Both researchers measured increased sensibility in the cranial posterior vaginal wall relative to the cranial anterior vaginal wall, but for all measurements, researcher 2 obtained higher sensibility ratings than researcher 1. In addition, researcher 2 found a decreased sensibility in the cranial anterior vaginal wall for women not using oral contraceptives. Phase of the menstrual cycle did not influence vaginal sensibility.

Conclusion: We developed a new instrument to measure vaginal wall sensibility. The instrument has excellent intra-observer reproducibility. This method is sufficiently sensitive so as to differentiate between anterior and posterior cranial vaginal wall sensibility, but outcome differs as a function of researcher. Further evaluation of the clinical use of this method is needed, provided that measurements are performed by the same researcher.
Introduction

Vaginal surgery may affect sexual function both positively and negatively. In the evaluation of effects on sexual function following gynaecological surgery, validated questionnaires have become the main outcome measurement. Questionnaires reflect, apart from the anatomical and physiological effects of the surgical intervention itself, the psychological effect of all intervention-related alterations. Part of the beneficial effects on sexuality of surgical interventions may be due to the elimination of disturbing factors, like menorrhagia, vaginal bulging or urinary incontinence, which negatively affect sexual well-being. However, not all studies investigating the effect of gynaecological surgery on sexuality have found an increased sexual function after surgery.

Sexual function is multi-factorial and involves psychological, contextual, anatomical and physiological aspects. Most outcome measures that are used nowadays to evaluate the effects of gynaecological surgery on sexual functioning are subjective outcome measures, for example disease specific questionnaires. To distinguish which factors are emotional or physiological and which factors are directly related to surgical trauma itself, there is a need for objective outcome measurements.

Several tools have been developed to assess vaginal sensibility. Vardi et al performed measurements with the Genitosensory Analyzer (medoc Advanced Systems) which is comprised of thermal and vibratory components. Vaginal and clitoral warm, cold, and vibratory sensory thresholds were measured in 89 healthy paid volunteers by the method of limits. However the published norms do not seem to make a large impact on the assessment of female sexual function. Also, the vibratory probes have no single contact surface but vibrate throughout, so no differences in innervation between different areas can be measured. The value of thermal thresholds in assessing vaginal sensibility is also still a matter of debate, since thermal stimuli are mediated by the small myelinated, group A beta vibers and vibrating stimuli by large vibers.

Yang et al reported a technique to measure sensory evoked potentials (SEP) of the dorsal nerve of the clitoris and the perineal nerve. The dorsal nerve of the clitoris was stimulated through self-adhesive disk electrodes on either side of the clitoris. Perineal nerve SEPs were evoked through a vaginal probe. Cortical responses were measured through cup electrodes affixed to the scalp at Cpz and Fpz. The use of this method is limited by its sensitivity and it only stimulates the distal part of the vagina at the introitus. The proximal part is not stimulated by this probe. Stimuli were delivered at a three times sensory threshold; women were only asked to localize the site of the stimuli. This method doesn’t allow for measurement of differences in sensibility pre- and post surgery.

Weijmar Schultz and co-authors also published a technique to measure vaginal sensibility. To stimulate the vaginal wall, they used a trofidur cylindrical tube on which two conical stainless steel tips were positioned 1 cm from the top of the tube with a diameter of 4 mm as the stimulating electrode and the indifferent electrode. They stimulated 12 different locations, 2 to 4 cm from the vaginal introitus, under nonerotic conditions. The most sensitive spot was found to be the ‘12-hour’ position (anterior vaginal wall). Unfortunately, they did not report on the inter- and intra-observer reproducibility of the technique.
We developed a technique to measure the sensibility of the vaginal wall consisting of a St Marks electrode on a gloved index finger, with a stimulating electrode mounted at the tip. Measurements were performed in four different target areas (caudal and cranial, posterior and anterior) by two independent female researchers in a random order.

According to several studies, oral contraceptive use and menstrual cycle phase may influence genital sensibility. During rectal sensibility measurement increased rectal sensibility was found in the follicular phase compared to the luteal phase\textsuperscript{13}. Nappi et al found that clitorial arterial peak systolic velocity was higher in women using oral contraceptives compared to women who did not\textsuperscript{14}.

The goal of this study was to investigate intra- and inter-observer reproducibility of this new method and to define possible influences of menstrual cycle phase and oral contraceptive use on vaginal sensibility.

**Patients and methods**

After approval of the ethical committee of the University Medical Centre Utrecht 12 healthy volunteers were recruited, they received travel allowance. Recruitment was done by an advertisement in the university journal. Women were excluded if they had vaginally delivered or if they had sexual problems or a history of sexual abuse. All volunteers completed a short questionnaire to document their medical history and to assess the presence of pelvic floor dysfunction.

All measurements were performed by two female researchers (researcher 1 and 2) in non-erotic circumstances. The method of instruction was standardized. Based on a computer generated randomization table, researcher 1 or 2 started with the measurements. All volunteers underwent measurements at two different time-points; once in the follicular phase and once in the luteal phase of the menstrual cycle. This was done to investigate hormonal effects on the vaginal wall sensibility. Both researchers performed measurements at both time-points.

A St Marks electrode fixed on a gloved index finger, with a stimulating electrode mounted at the tip and a recording electrode mounted at the base was used\textsuperscript{15}. This electrode has been developed to measure pudendal nerve terminal motor latency. For the measurements in this study we only used the stimulating electrode at the tip. By attaching the tip on the top of a gloved index finger it was possible to accurately approach the target location in the vagina. We identified 4 target locations: caudal anterior: three centimeter from the introitus in the midline on the anterior vaginal wall; caudal posterior: three centimeter from the introitus in the midline on the posterior vaginal wall; cranial anterior: most cranial part of the anterior vaginal wall in the midline (fornix anterior), and cranial posterior: most cranial part of the posterior vaginal wall in the midline (fornix posterior).

To measure vaginal sensibility, the index finger with the electrode on top was placed on the target location without pushing to the wall to realize minimal pressure. To avoid order effects, the target locations were stimulated in according to a computerized random order. A constant current (square wave stimuli, 100 msec, 5 pulses per second) was increased gradually from 1 to 40...
milli-Ampere (mAmp) until threshold of sensation was indicated by the volunteer. Intensity was gradually increased. We used the method of limits as it is the shortest and easiest to understand of all quantitative sensory testing methods. As the measurement includes reaction time, the real threshold will be of some lower value.

For the settings of the square wave stimuli we adapted those of the measurement of anal sensitivity. The aim of our stimulation was to provoke a sensation of vibration and not of pain. Each measurement was repeated three times. The time between the measurements was 10 seconds. The first measurement was not included to allow the volunteer to get used to the sensation of the stimulus and to limit the interval between sensation and response.

In a short pilot study to test the feasibility of this new measurement it was observed that in the cranial part of the vagina the first sensation during increasing current was sometimes not only a sensation of vibration but also a sensation of pain. We therefore tested the sensibility of the cranial part of the vagina with two different settings. One setting was adapted from anal sensitivity testing (square wave stimuli, 100 msec, 5 pulses per second) and one setting was adapted from rectal sensitivity testing (square wave stimuli, 500 msec, 10 pulses per second).

As none of the volunteers experienced a painful sensation during the settings adapted from rectal sensitivity testing, we adhered to these settings for sensitivity measurements of the cranial part of the vagina.

**Statistical analysis**

Data were carefully checked for outliers, none were detected. To quantify the intra- and inter-observer reproducibility of the measurement Pearson-Rho coefficients were calculated. A Pearson-Rho coefficient expresses the correlation between two continuous variables. The intra-observer reproducibility was determined per location for both researchers separately by calculating the correlation between each second and third measurement. A paired t-test was also conducted to be sure that no statistical significant differences were found between the second and third measurement per location per researcher. The inter-observer reproducibility was determined per location by calculating the correlation between each measurement of researcher 1 and 2.

Analysis of variances (ANOVA) was used to test the effects of different factors and their interactions on vaginal sensibility. F-ratios were calculated. Factors included in this analysis were target location (anterior or posterior), researcher, use of oral contraception, and menstrual cycle phase (follicular or luteal phase). Because cranial and caudal measurements were conducted at different settings, this ANOVA was run for cranial and caudal measurements separately. Two- and three-way interactions between these variables were included in the ANOVA model. A p-value of < 0.05 was considered to be statistically significant. The statistical package used to perform the analyses was SPSS 16.0.
Results

Mean age of the 12 volunteers was 23.9 years (standard deviation 5.2 years). Half of these volunteers used oral contraception. None of the volunteers suffered from micturition and defecation symptoms. One of the volunteers reported urgency and one other volunteer reported constipation. None of the volunteers reported sexual problems.

In Table 1 the intra- and inter-observer reproducibility of our measurement per location is expressed by the Pearson-Rho coefficient. The intra-observer reproducibility of researcher 1 and 2 was almost perfect. The inter-observer reproducibility was moderate. Because no statistical significant differences were found between the second and third measurement in each location and intra-observer reproducibility was very high, we used the mean of the second and third measurement in further analyses.

In table 2 the mean sensibility for each location is shown. As different settings were used for measurements in the cranial and caudal part of the vagina, the values of the cranial measurements cannot be compared to the values of the caudal measurements.

Table 1. Intra- and inter-observer agreement.

<table>
<thead>
<tr>
<th></th>
<th>Intra-observer agreement Researcher 1</th>
<th>Intra-observer agreement Researcher 2</th>
<th>Inter-observer agreement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Caudal anterior wall</td>
<td>0.88 *</td>
<td>0.96 *</td>
<td>0.42</td>
</tr>
<tr>
<td>Caudal posterior wall</td>
<td>0.90 *</td>
<td>0.95 *</td>
<td>0.39</td>
</tr>
<tr>
<td>Cranial anterior wall</td>
<td>0.93 *</td>
<td>0.81 *</td>
<td>0.49 *</td>
</tr>
<tr>
<td>Cranial posterior wall</td>
<td>0.96 *</td>
<td>0.77 *</td>
<td>0.46</td>
</tr>
</tbody>
</table>

Values are Pearson-Rho correlation coefficient
* = p < 0.001

ANOVA was used to detect the main effects and two, three-way interactions on vaginal sensibility measurement. In caudal measurements the vaginal sensibility was affected by the researcher (F (1,10) = 6.89, p< 0.03, partial η2 = 0.41, observed power = 0.66). Similarly, in cranial measurements a main effect of researcher was found (F (1,10) = 10.09, p< 0.01, partial η2 = 0.50, observed power = 0.82) and a main effect of location (F (1,10) = 25.69, p < 0.0005, partial η2 = 0.72, observed power = 0.995). Both researchers measured increased sensibility in the cranial posterior vaginal wall relative to the cranial anterior vaginal wall, but for all measurements, researcher 2 obtained higher sensibility ratings than researcher 1. For cranial measurements these main effects were modified by a researcher, location, and use of oral contraceptives three-way interaction (F (1,10) = 6.22, p < 0.05, partial η2 = 0.38). Only for researcher 2, sensibility in the anterior vaginal wall, but not in the posterior vaginal wall, was lower in women not using oral contraceptives. No other main or interaction effects were found.

We also performed a separate ANOVA in which women using oral contraceptives were excluded, to further evaluate the influence of time point in menstrual cycle. No influence of time point in menstrual cycle was found.
In this manuscript we present a new method of quantitative sensory testing to measure vaginal sensibility. In the cranial part of the vaginal wall we found a significant increased sensibility of the posterior wall. This is in line with findings of Alzate et al and Laan et al.\textsuperscript{19, 20}. We could not confirm the findings of other reports suggesting that the anterior vaginal wall is more sensitive than the posterior vaginal wall\textsuperscript{21}. Hilliges et al found, during a immunohistochemical study, that the innervation of the caudal part of the anterior and posterior wall did not differ, we did not observe a difference in sensibility between caudal anterior and posterior vaginal wall\textsuperscript{22}. These findings were moderated by researcher main effects for both caudal and cranial sensibility, and an interaction of location x researcher x use of oral contraceptive for cranial measurements. This interaction was mainly explained by measurements of researcher 2 who found a decreased sensibility in the anterior vaginal wall for women not using oral contraceptives. This was not found in the posterior wall or in the measurements of researcher 1. Therefore this interaction might also be largely explained by inter-observer variation.

The variation in sensibility as a function of the researcher performing the measurements can probably be best explained by the variance in the force the researchers exerted to the vaginal wall or in the angle between the St Marks electrode and the vaginal wall. Our method has almost excellent intra-observer reproducibility, therefore one option to diminish the researcher effect might be to have one researcher performing all measurements. However, the best option seems to eliminate human factors from the measurement entirely. We are therefore currently testing a newly developed probe mounted with electro-stimulation electrodes\textsuperscript{20}. This probe also allows for simultaneous vaginal pulse amplitude- and pelvic floor electromyography measurements\textsuperscript{23}. Depth and orientation of the probe is controlled by a 9 x 2-cm acrylic plate and can be placed in the vagina by the subject herself. The probe remains positioned in an unaltered fashion during measurements, as such avoiding variation in force as a function of pressure.

Phase of the menstrual cycle did not influence vaginal sensibility. This is in contrast with measurement of rectal sensibility, which have shown an higher sensibility in the follicular phase than in the luteal phase\textsuperscript{13}. The fact that we could not confirm such effects of cycle on sensibility could be explained by the fact that half of the group used oral contraceptives which suppresses

### Table 2. Mean vaginal sensibility scores (in milli-Amperes) of the four different locations.

<table>
<thead>
<tr>
<th>Location</th>
<th>Mean</th>
<th>95% CI</th>
<th>p-value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Caudal</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anterior</td>
<td>10.2</td>
<td>9.3-11.1</td>
<td>0.41</td>
</tr>
<tr>
<td>Posterior</td>
<td>11.0</td>
<td>10.1-11.9</td>
<td></td>
</tr>
<tr>
<td>Cranial</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anterior</td>
<td>8.0</td>
<td>7.1-8.9</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Posterior</td>
<td>5.8</td>
<td>4.9-6.8</td>
<td></td>
</tr>
</tbody>
</table>

* P-value of difference in mean between posterior and anterior measurement.
Note: different settings were used for cranial and caudal measurements.
normal menstrual cycle. However even if women using oral contraception were excluded, the menstrual cycle appeared to not effect vaginal sensibility. Different findings in the follicular and luteal phase would have implicated that consecutive measurements in an individual always would have to be planned in the same phase. This finding and the absence of any measurement order adds to the applicability of the presented method.

The sensation of touch, light pressure, and vibration are conducted by large myelinated fibers in peripheral nerves and by the dorsal column of the spinal cord\textsuperscript{10,24}. These large fibers are most relevant as their dysfunction could affect the sensory modalities that are important for female sexual function. All volunteers experienced the stimulus as a vibration sensation. None of the volunteers reported to have perceived the electric pulse as an erotic stimulus. This means that the large myelinated A-alpha and A-beta sensory fibers are stimulated. Rarely a painful sensation accompanied the sensation of vibration. If this happened, it happened at higher pulse wave amplitudes. This indicates that at higher amplitudes the small myelinated and/or unmyelinated fibers are stimulated as well. As the sensation of pain could most of the time not be reproduced in the same volunteer at the same location we argue that the presented method is predominantly a test to assess damage to the small nerve endings of the large myelinated fibers.

One could argue that pressing the electrode against the vaginal wall provides additional stimulation of the large myelinated fibers. Even though the researchers were instructed to keep the electrode against the vaginal wall without providing additional pressure, the main effect of researcher and the researcher x location x oral contraception use that was found suggests that it is difficult to avoid differences in pressure of the electrode with this method.

In an unpublished pilot study we also attempted to measure the innervation of the clitoris, as sensibility of the clitoris plays an important role in sexual functioning. However, stimulation of the clitoris using a St Marks electrode generated a painful sensation during most of the measurements. This may be due to the more complex innervation of the clitoris containing both large-, small- and un-myelinated fibers of pelvic, pudendal, and hypogastic nerves. Another explanation for the painful sensations during stimulation of the clitoris may be that we did not find the optimal measurement settings. During vaginal wall stimulation, using non-optimal settings, the electric pulse frequently resulted in a painful sensation apart from a sensation of vibration.

This new method to measure vaginal sensibility was developed to evaluate the effects of vaginal surgery on sexual function in prospective studies. However, if measurements before and after intervention are performed by different researchers, the moderate inter-observer agreement will be a limitation. As the intra-observer agreement of our method is excellent, such limitations would not exist if measurements before and after intervention would be performed by the same researcher. The measurement might also be influenced by the setting of the measurement itself. However this influence is the same before and after intervention. To evaluate the influence of vaginal sensibility on sexual function, future research has to compare vaginal sensibility with validated questionnaires in healthy women and women with sexual dysfunction.
Conclusion

Our method was developed for implementation as an outcome measure in clinical studies. We tested different variables which might affect vaginal sensibility. A main effect was found of researcher, however, a difference in vaginal sensibility in different locations could still be shown. An excellent intra-observer reproducibility was found, but measurements were affected by human factors. Future research has to establish the relationship between the measurement of vaginal sensibility and subjective sexual function.
References

20. Laan E, Lunsen van R, Roovers JP. Vaginal sensibility in women with and without a hyperactive pelvic floor. 209 manuscript in preparation.