Pelvic floor symptoms after gynaecological surgery
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Chapter 9

The effects of prolapse surgery on vaginal wall sensibility, vaginal vasocongestion and sexual function: a prospective single center study

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Submitted
Abstract

Objective: Prolapse surgery has been shown to positively alter body image and decrease pelvic floor symptoms, hereby possibly improving sexual function. However, the surgical trauma itself may adversely affect sexual function, by damaging innervation and vascularisation of the vagina and its surrounding tissues. Hence, there is a need for objective outcome measurements to better understand the effects of prolapse surgery on sexual function.

Methods: A prospective study was performed, including patients scheduled for vaginal prolapse surgery. Participants underwent measurements before and 6 months after surgery, during non-erotic and erotic visual stimuli, using a validated vaginal combi-probe. This combi-probe includes vaginal photoplethysmography to assess Vaginal Pulse Amplitude (VPA) (representing vaginal vasocongestion), and four pulse-generating electrodes to measure vaginal wall sensibility (representing vaginal innervation). Sexual function was assessed using validated questionnaires (FSFI, FSDS-R, SSAQ). Pre- and postoperative vaginal vasocongestion, vaginal wall sensibility and sexual function scores were compared.

Results: Twenty-nine women were included, 24 (83%) completed the six months follow-up visit. VPA analysis showed a significant reduction in vaginal vasocongestion during sexual stimulation post-operatively (pre-op 2.4 mV (SD 2.5) vs post-op 1.7mV (SD2.4), p=0.05). Vaginal wall sensibility in the cranial posterior vaginal wall was significantly reduced after surgery (pre-op 13.3mA vs post-op 17.5mA, p<0.05), On the other locations vaginal wall sensibility was not affected by surgery. Sexual function as assessed with questionnaires, was not significantly affected.

Conclusion: Prolapse surgery negatively impacted levels of vaginal vasocongestion during sexual stimulation as well as vaginal wall sensibility in the cranial posterior vaginal wall, but sexual function as assessed by questionnaires, did not seem to alter. Future studies are needed to tease out the contribution of psychological and physiological factors on sexual function.
Vaginal wall sensibility and vasocongestion after prolapse surgery

Introduction

Pelvic organ prolapse is a common condition affecting micturition, defecation and sexual function\textsuperscript{1,2}. When symptoms are severe enough, prolapse surgery is performed to correct anatomical abnormalities. The intention of such procedures is to restore anatomical abnormalities, and hereby improve symptoms of micturition, defecation and sexual function. However, previous studies did not consistently find improvement in sexual function after vaginal prolapse surgery, with some studies showing improvement\textsuperscript{3-9}, others showing no impact of surgery on sexual function\textsuperscript{10-13}, or a worsening of sexual function\textsuperscript{14,16}. Most of these studies used validated questionnaires to evaluate sexual function. These questionnaires mainly assess psychological and interpersonal aspects of sexual function. Sexual function, however, also depends on intact vaginal innervation and vasocongestion\textsuperscript{17-19}, and to date, the effect of prolapse surgery on these indices is unknown.

During sexual stimulation increased vaginal vasocongestion causes clitoris engorgement and subsequent lubrication. The same occurs for the vagina, which becomes engorged during sexual stimulation and forms a plasma transudate that is critical during the sexual arousal phase\textsuperscript{2,15,18,19}. The autonomic innervation responsible for this response to sexual stimuli originates from the pelvic plexus and travels within the uterosacral and cardinal ligaments\textsuperscript{20}.

Prolapse surgery may impact on vaginal vasocongestion and innervation in various ways. The extensive dissection of the vaginal epithelium and fascia, that is performed during colporraphy, may affect the free nerve endings in the vaginal epithelium and damage the peripheral blood vessels, which are important for vaginal lubrication\textsuperscript{19,21}. Furthermore, during sacro-spinous ligament fixation, the pudendal nerve might be at risk for damage due to indirect surgical trauma, as the pudendal nerve is closely related to the sacro-spinous ligament. Also, overstretching of the vagina might induce a constant input to the afferent nerves causing the afferents to be less sensitive to other stimuli. Lastly, downwards traction during vaginal surgery may cause damage to the innervation\textsuperscript{22-24}.

To assess surgery-related damage, our group has developed and validated a method to measure vaginal wall sensibility\textsuperscript{25}. The method was incorporated in a standard probe used for vaginal photoplethysmography. This enabled us to measure vaginal wall sensibility concurrent with Vaginal Pulse Amplitude (VPA), which is a validated method to measure vaginal vasocongestion\textsuperscript{26}.

The first aim of this study is to evaluate the effect of prolapse surgery on vaginal vasocongestion and vaginal wall sensibility. The second aim is to evaluate if sexual dysfunction was related to diminished vaginal vasocongestion and innervation.

Materials and methods

We performed a single-centre, prospective, observational study. Patients scheduled for vaginal prolapse surgery were asked to participate in this study. Exclusion criteria were: prior bowel surgery or pelvic surgical procedures, a history of sexual abuse or pre-existing sexual dysfunction,
use of medication that affects sexual wellbeing, diabetes mellitus, hypertensive disorders with vascular disease and presence of a depressive disorder. During a brief telephone interview patients were screened for the presence of any of the exclusion criteria. Depressive symptoms were assessed using the Dutch adaptation of the Beck Depression Inventory- short form, patients were excluded if they scored 14 points or more on this questionnaire\textsuperscript{27,28}. During the visit to the outpatient clinic, all patients were asked if they had any complaints regarding sexual function. If a patient reported her sexual function to be impaired she was excluded from the study.

The study protocol was approved by the local Medical Ethics committee of the Academic Medical Centre Amsterdam and written informed consent was obtained from all patients.

**Surgical procedure**

Only women scheduled for conventional prolapse surgery (i.e. without the use of Mesh material) were included. Prolapse surgery was performed according to standardized surgical protocol\textsuperscript{29}, all patients were operated by the same gynaecologist. Peri-operative treatment was the same in all participating patients. Patients underwent anterior colporrhaphy in case of stage 2 cystocele or more (POP-Q classification), posterior colporrhaphy in case of stage 2 rectocele or more and sacro-spinous ligament fixation in case of middle compartment prolapse. In our clinic we prefer sacrospinous fixation over vaginal hysterectomy as surgical correction of apical prolapsed, considering the lower risk of complications and similar recurrence rate\textsuperscript{30}.

**Figure 1.** Vaginal combi-probe which is used during this study to measure vaginal vasocongestion and vaginal wall sensibility.

**Measurement of vaginal innervation and vaginal vasocongestion**

All women were asked to undergo measurements of vaginal innervation and vaginal vasocongestion using the vaginal combi-probe (figure 1). This device, sized and shaped as a menstrual tampon, could easily be inserted by the patient herself. The device contains a
light source and an optical sensor to measure Vaginal Pulse Amplitude (VPA), and four pulse-generating electrodes to measure vaginal wall sensation threshold. Depth of the combi-probe and orientation of the light source were controlled by a device (a 9x2-cm persplex plate) attached to the cable within 5cm of the optical sensor. Patients were instructed to insert the combi-probe such that the plate touched their labia. The probe and plate were sterilized in a solution of Cidex-activated glutaraldehyde (CidexOPA; Johnson and Johnson, Amersfoort, The Netherlands).

Psychophysiological assessment.
* VPA. VPA is a validated method to assess phasic changes in vaginal vasocongestion in the peripheral vessels with every heart beat. Increased amplitudes are indicative of increased vaginal vasocongestion26.
* Vaginal wall sensibility. Four pulse generating electrodes were used to assess vaginal wall sensibility. These were mounted at the probe at four different locations: three and six centimetres from the introitus in the midline on the anterior and posterior vaginal wall. These four electrodes separately provided a constant current stimulus which was gradually increased in intensity (0-100 mAmpere) until the threshold of sensation was indicated by the patient. Higher values indicate a higher threshold of sensation, and a diminished vaginal wall sensibility. The four locations were stimulated in a random order. Each measurement was repeated three times, the first measurement was not included in the analysis to allow the patient to become acquainted with the sensation of the stimulus and to limit the interval between sensation and response. This method was validated in a previous study25.

Questionnaires.
1. Subjective sexual arousal and affect questionnaire (SSAQ)26. Immediately following erotic film exposure participants filled out a 37-item questionnaire measuring sexual feelings and affect, consisting of 5 scales: sexual arousal (Cronbach’s α=0.87); genital sensations (Cronbach’s α=0.96); sensuality (Cronbach’s α=0.73); positive affect (Cronbach’s α=0.93); and negative affect (Cronbach’s α=0.65). Each question was preceded by the sentence: “During the video, I felt:” after which a positive, negative, physical or sexual experience was described, for instance, pleasant; worried; genital pulsing or throbbing; sexually aroused. The items were measured on a 1 (not at all) to 7 (intensely) scale.
2. The Female sexual Function Index (FSFI): This is a validated questionnaire evaluating sexual function31. The questionnaire consists of 6 domain scores: desire, arousal, lubrication, orgasm, satisfaction and pain. The total score range is 2-36, with higher scores indicating better sexual functioning. The psychometric quality of the Dutch version is as satisfactory as the original version32.
3. The Female Sexual Distress Scale- Revised (FSDS-)33,34. This is a validated questionnaire consisting of 13 questions assessing the level of sexual problems-related distress33. A total score is calculated, with higher scores indicating a higher level of distress. Again, the psychometric quality of the Dutch version is as satisfactory as the original version33.
Study procedure
Objective and subjective measurements were performed one to six weeks before surgery, and six months after surgery. This post-operative period was chosen based on a study providing evidence that innervation damage can recover up to six months after a pelvic floor trauma. The experiment was carried out by a female researcher. During the whole experiment the patient was alone in the laboratory, with the researcher in the adjacent room. Patients were instructed to insert the probe and take a seat in front of the monitor. First, baseline value was determined by showing a non-erotic documentary for 3 minutes. After that, the VPA measurements were performed under neutral and erotic conditions using film fragments. The 3 minute neutral film excerpt was taken from “Pearls of the Caribbean”. The 3 minute sexual film excerpt consisted of an erotic scene taken from erotic films known to significantly increase vaginal vasocongestion and subjective sexual arousal, depicting foreplay, cunnilingus, and intercourse (One size fits all by Candida Royalle). After each fragment the patient was asked to fill out the SSAQ. At the end of the VPA measurements the non-erotic film was continued to allow genital response to return to baseline. If after two minutes, genital response had not returned to baseline level, patients were asked to count backwards until baseline level was reached. Subsequently another three minute neutral film fragment was shown. After this neutral film fragment the measurements of vaginal wall sensibility were performed.

Two versions (A and B) were made containing comparable, but different, neutral and erotic film fragments. Half of the subjects were randomly allocated to version A for the pre-surgery test and version B for the post surgery test. The other half was allocated to the stimulus versions in the reverse order.

Power calculation
In a previous study using an electrode attached to the investigator’s finger to assess vaginal wall sensibility, we found a decrease in vaginal wall sensibility after vaginal hysterectomy combined with anterior and/or posterior colporrhaphy with an effect size of 0.30. Another study in women who underwent proctocolectomy with ileo-anal pouch anastomosis, we found vaginal vasocongestion to be significantly decreased 6 months after surgery, with a median effect size (d=0.25). With an alpha of 0.05, a power of 80% and an effect size of 0.25 a minimum of 18 patients is needed for the within subject effect. Therefore we aimed to include 18 patients in this study.

Data reduction
VPA was registered during the entire experiment. Data were entered into a computer program developed at the Department of Psychology, University of Amsterdam. After VPA artefact deletion, peak-to-through amplitude was calculated for each remaining pulse, averaged over 10-s epochs and converted to mV. Mean VPA values (VPA\text{mean}) for neutral film stimuli were computed by averaging peak-to-through amplitudes across the entire duration of each 3-min film. An increased peak-to-through amplitude indicates increased vaginal vasocongestion. VPA\text{response} was calculated by subtracting the participant’s VPA\text{mean} value during exposure.
to the erotic film stimulus, minus the participant’s VPAmean value of the preceding neutral film fragment.
Domain scores of the FSFI, the total FSFI score, the total FSDS-R score and SSAQ domain scores were calculated.

Statistical analysis
Pre- and postoperative VPAmean, vaginal sensation thresholds, SSAQ scores and domain scores of the FSFI and FSDS-R were compared using a Wilcoxon signed rank test for paired data, median and range were reported. Sub-group analyses were performed for every different type of surgical procedure. To inspect possible increases over time in mean change in VPA response to erotic film exposure (VPAresponse), the 10-second VPA epochs were submitted to a 2 (pre- and post-operative) x 15 (change in response over time) repeated measures ANOVA.
To evaluate if changes in vaginal sensation thresholds, VPAmean and VPAresponse were related to sexual dysfunction, we dichotomized the pre-, and post-operative total FSFI score into normal (FSFI total score > 26.55) and dysfunctional (FSFI total score < 26.55) and compared sensation thresholds, VPAresponse and VPAmean between these two groups using a Mann-Whitney-U test.

Table 1. Patient characteristics and performed procedures.

<table>
<thead>
<tr>
<th></th>
<th>N=29</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median BMI in kg/m²</td>
<td>25.4 (20.1-34.2)</td>
</tr>
<tr>
<td>Median age in years</td>
<td>52.2 (38.1-62.8)</td>
</tr>
<tr>
<td>Parity (n)</td>
<td>2 (1-4)</td>
</tr>
<tr>
<td>Menopausal status</td>
<td></td>
</tr>
<tr>
<td>Postmenopausal</td>
<td>15 (52%)</td>
</tr>
<tr>
<td>Premenopausal</td>
<td>12 (41%)</td>
</tr>
<tr>
<td>Unknown</td>
<td>2 (7%)</td>
</tr>
<tr>
<td>Performed procedure</td>
<td></td>
</tr>
<tr>
<td>Anterior colporhaphy (AC)</td>
<td>9 (31%)</td>
</tr>
<tr>
<td>Posterior colporhaphy (PC)</td>
<td>7 (24%)</td>
</tr>
<tr>
<td>Sacro-spinous ligament fixation (SSLF)</td>
<td>2 (7%)</td>
</tr>
<tr>
<td>AC+ PC</td>
<td>3 (10%)</td>
</tr>
<tr>
<td>SSLF+AC</td>
<td>6 (21%)</td>
</tr>
<tr>
<td>SSLF+PC</td>
<td>2 (7%)</td>
</tr>
</tbody>
</table>

Results

In total, 99 women were asked to participate. Twenty-nine women agreed to participate (29% participation rate), 24 of whom completed the six months follow-up visit. It proved to be difficult to recruit patients for this study, most women refused because they did not want to be questioned about sexual function and did not want to be exposed to erotic film material. Other patients declined because they felt that the study would take too much of their time. Baseline
characteristics of the participants, including the performed surgical procedures, are shown in Table 1.

**Figure 2.** Pre- and post-operative mean increase in vaginal pulse amplitude (VPA) response during erotic visual stimuli relative to preceding neutral film.

![Graph showing pre- and post-operative mean increase in vaginal pulse amplitude (VPA) response during erotic visual stimuli relative to preceding neutral film.](image)

* Repeated measures ANOVA showed a negative effect of the operation (p=0.05)

**Vaginal vasocongestion**

VPA_{mean} values during neutral film were significantly lower post-operatively (median 1.3 mV (range 0.3-3.2mV)) than pre-operatively (median 1.8 mV (range 0.6-6.4)) (p< 0.01). The repeated measures ANOVA showed a significant increase in VPA_{response} during erotic film (p<0.01) (Figure 2). There was a significant negative effect of the operation (p=0.05) such that postoperative scores were lower than preoperative scores (figure 2). The operation x change in response over time interaction was not significant (p=0.95), indicating that even though mean postoperative scores were lower, the increase in VPA during erotic stimulation occurred at the same rate postoperatively and preoperatively.

**Table 2.** Pre- and post-operative median vaginal sensation thresholds (in mA).

<table>
<thead>
<tr>
<th></th>
<th>Pre-operative (N=29)</th>
<th>Post-operative (N=24)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Median (range)</td>
<td>Median (range)</td>
<td></td>
</tr>
<tr>
<td>Cranial posterior wall (in mA)</td>
<td>13.3 (4.3-72.8)</td>
<td>17.5 (1.8-99.9)</td>
<td>0.05</td>
</tr>
<tr>
<td>Cranial anterior wall (in mA)</td>
<td>21.8 (3.4-90.0)</td>
<td>24.2 (1.8-98.8)</td>
<td>0.51</td>
</tr>
<tr>
<td>Caudal posterior wall (in mA)</td>
<td>5.8 (2.6-38.2)</td>
<td>6.4 (1.0-57.2)</td>
<td>0.30</td>
</tr>
<tr>
<td>Caudal anterior wall (in mA)</td>
<td>8.3 (2.4-33.9)</td>
<td>6.0 (1.0-41.4)</td>
<td>0.86</td>
</tr>
</tbody>
</table>
Vaginal wall sensibility

Sensation thresholds before and after surgery are shown in Table 2. After surgery a statistically significant increase in sensation threshold was found in the cranial posterior vaginal wall, indicating decreased vaginal wall sensibility.

Table 3. Pre- and post-operative median vaginal sensation thresholds (in mA).

<table>
<thead>
<tr>
<th></th>
<th>Pre-operative (N=29)</th>
<th>Post-operative (N=24)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sexual arousal</td>
<td>3.0 (1.0-6.3)</td>
<td>3.3 (1.7-4.7)</td>
<td>0.65</td>
</tr>
<tr>
<td>Genital sensation</td>
<td>2.9 (1.0-6.7)</td>
<td>3.8 (1.0-6.3)</td>
<td>0.22</td>
</tr>
<tr>
<td>Sensuality</td>
<td>2.6 (2.0-3.4)</td>
<td>2.6 (2.2-3.6)</td>
<td>0.70</td>
</tr>
<tr>
<td>Positive affect</td>
<td>2.5 (1.0-6.4)</td>
<td>2.4 (1.0-5.6)</td>
<td>0.90</td>
</tr>
<tr>
<td>Negative affect</td>
<td>1.3 (1.0-3.3)</td>
<td>1.5 (1.0-2.8)</td>
<td>0.40</td>
</tr>
</tbody>
</table>

Note: Scale ranges from 1 (not at all) to 7 (intensely)

Sexual function

Table 3 shows pre- and postoperative subjective sexual arousal and affect after erotic film viewing. Subjective sexual arousal and affect were found to be unaffected by surgery.

Table 4 shows the results of the FSFI before and after surgery. Despite the fact that none of the included patients reported bothersome sexual symptoms prior to surgery, the pre-operative median total FSFI score was within the dysfunctional range. We found no statistically significant change in sexual function after surgery. After surgery the median FSFI total score was still within the dysfunctional range. We found a trend towards increased scores on the FSFI pain domain after surgery (p=0.06), indicative of a reduction in sexual pain.

Table 4. Pre- and post-operative Female Sexual Function Index (FSFI) domain- and total scores and the Female Sexual Distress Scale-Revised (FSDS-R) total score.

<table>
<thead>
<tr>
<th></th>
<th>Pre-operative (N=26)</th>
<th>Post-operative (N=24)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>FSFI domain scores</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Desire</td>
<td>3.0 (1.2-4.8)</td>
<td>3.0 (1.2-4.8)</td>
<td>0.80</td>
</tr>
<tr>
<td>Arousal</td>
<td>3.3 (0.0-6.0)</td>
<td>4.1 (0.0-6.0)</td>
<td>0.89</td>
</tr>
<tr>
<td>Lubrication</td>
<td>3.9 (0.0-6.0)</td>
<td>5.3 (0.0-6.0)</td>
<td>0.39</td>
</tr>
<tr>
<td>Orgasm</td>
<td>4.4 (0.0-6.0)</td>
<td>4.8 (0.0-6.0)</td>
<td>0.81</td>
</tr>
<tr>
<td>Satisfaction</td>
<td>4.0 0.8-6.0</td>
<td>4.8 (1.2-6.0)</td>
<td>0.61</td>
</tr>
<tr>
<td>Pain</td>
<td>3.0 (0.0-6.0)</td>
<td>5.2 (0.0-6.0)</td>
<td>0.06</td>
</tr>
<tr>
<td>FSFI Total score</td>
<td>20.5 (0.0-34.2)</td>
<td>23.3 (1.2-32.2)</td>
<td>0.30</td>
</tr>
<tr>
<td>FSDS-R Total score</td>
<td>18.0 (0.0-104.0)</td>
<td>11.5 (0.0-38.0)</td>
<td>0.25</td>
</tr>
</tbody>
</table>

Note: For the FSFI, lower scores indicate worse sexual functioning. For the FSDS-R, lower scores indicate less sexual distress.

Per surgical procedure analysis

To further explore which surgical procedures are related to the greatest change in physiological
parameters and sexual function, we performed an exploratory subgroup analyses for each of the six different combinations of surgical procedures.

Figure 3 shows the \( \text{VPA}_{\text{mean}} \) values, before and after surgery, under erotic and neutral conditions, for each of the six performed combinations of surgical procedures. For VPA during erotic film, there is a consistent decline in \( \text{VPA}_{\text{mean}} \) values post-surgery for each surgical procedure. We found that this decline was only statistically significant for sacro-spinous ligament fixation combined with anterior colporraphy (\( p<0.05 \)).

Figure 4 shows the sensation thresholds, before and after surgery, in the cranial posterior vaginal wall, for the six different performed combinations of surgical procedures. As with \( \text{VPA}_{\text{mean}} \), we found a significant post-operative increase in sensation threshold for sacro-spinous ligament fixation combined with anterior colporraphy (\( p<0.05 \)). For the other combinations of surgical procedures, the sensation threshold was not significantly altered.

Sexual function, as measured with the FSFI, FSDS-R and SSAQ did not significantly alter for any of the six combinations of surgical procedures.

**Figure 3a & b.** Mean vaginal pulse amplitude (VPA) during the neutral (1a) and erotic (1b) film fragment before and after surgery broken down by surgical procedure.

\* AC= Anterior colporraphy; PC= Posterior colporraphy; SSLF= Sacro-spinous ligament fixation

**Sexual (dys)function and physiological parameters**

Vaginal vasocongestion and vaginal wall sensibility seemed to decrease after surgery, whereas we could not show changes in sexual function. Before surgery most women had FSFI scores within the dysfunctional range, after surgery this was still the case for most women.

Pre-operatively, 17 women had FSFI scores within the dysfunctional range and 9 women had FSFI scores within the functional range. For three women insufficient scores were available to calculate a total score. Post-operatively, 14 women had FSFI scores within the dysfunctional range, 12 of them were also dysfunctional before surgery and two had become dysfunctional.

To evaluate if women with dysfunctional FSFI scores differed in physiological parameters from
women with normal FSFI scores, we compared physiological parameters between these two groups of women. No differences in $VPA_{\text{mean}}$, $VPA_{\text{response}}$ and vaginal wall sensibility were found between these two sexual function groups.

**Figure 4.** Mean sensation threshold in the proximal posterior vaginal wall before and after surgery broken down by surgical procedure.

![Graph showing mean sensation threshold in the proximal posterior vaginal wall before and after surgery broken down by surgical procedure.](image)

* AC= Anterior colporraphy, PC= Posterior colporraphy, SSLF= Sacro-spinous ligament fixation

**Discussion**

This is one of the first studies to explore the effects of prolapse surgery on vaginal physiology and sexual function, and the first study to simultaneously measure vaginal wall sensibility and vaginal vasocongestion.

We found that, as compared to before vaginal prolapse surgery, vaginal vasocongestion under neutral and erotic conditions decreased after surgery. Vaginal wall sensibility in the cranial posterior vaginal wall, one of the four measured area’s, was also decreased post-surgically. Sexual function as assessed with questionnaires did not seem to alter.

Before further interpreting these results, some limitations need to be addressed. The main limitation of this study is the small sample size. Our power calculation indicated that we needed at least 18 patients to detect a statistical significant difference in $VPA_{\text{mean}}$ values, which we used as measurement of vaginal vasocongestion. We were able to 29 women in total, but for the exploratory subgroup analyses of the different performed surgical procedures the numbers...
are too small to be really confident about the meaning of the findings. At least another 70 women were approached to participate and refused, showing that studies like these are difficult to realize. Most women refused because they did not want to be questioned about sexual function and did not want to be exposed to erotic film material. The nature of this study may therefore have introduced a volunteer bias as it is known that patients willing to participate in a sexuality study have a more positive attitude towards sexuality and are more sexually active\textsuperscript{38}. This is particularly true for subjects who are asked to undergo a study with psychophysiological assessments. Patient characteristics of participants were comparable to those of patients in previous studies among women scheduled for prolapse surgery, but this does not exclude a selection bias\textsuperscript{39,40}. Based on our inclusion criteria for bothersome sexual complaints, this was not a sample regarded itself as being sexually dysfunctional. Nevertheless, the sample was largely dysfunctional according to the validated cut off score of the FSFI. This questionnaire is a widely used and internationally accepted measure for measuring sexual function\textsuperscript{41}. Of note, at the time of study start a validated Dutch translation of the Pelvic Organ Prolapse/Urinary Incontinence Sexual Questionnaire (PISQ), a widely used measure specifically designed to assess functional differences in women with prolapse, was not available.

The strength of this study is that simultaneous measurements of vaginal wall sensibility and vaginal vasocongestion were performed, before as well as after prolapse surgery. This prospective design allowed us to detect differences in vaginal innervation and vaginal vasocongestion related to prolapse surgery. Furthermore, given the lack of an absolute reference for VPA and the known measurement variation between patients, this prospective design enabled us to use women as their own controls.

We found that prolapse surgery negatively impacted vaginal vasocongestion as well as vaginal wall sensibility in the cranial posterior vaginal wall. An explanation for this finding may be that during vaginal prolapse surgery the free nerve endings in and near the vaginal epithelium are affected due to trauma during dissection of the vaginal epithelium. The afferent impulses from these nerves are important in enhancing vaginal vasocongestion through activation of spinal autonomic pathways\textsuperscript{42}. Furthermore, VPA mainly assesses vaginal vasocongestion in the total peripheral microcirculation. This microcirculation seems particularly prone to damage as a result of direct trauma during the dissection and traction applied to the tissue.

It is impossible to compare the observed decrease in vaginal vasocongestion with previous studies, since there are no previous studies evaluating the effects of prolapse surgery on vaginal vasocongestion. A few studies have reported on changes in vaginal vasocongestion after other surgical procedures in the pelvic cavity\textsuperscript{37,43-45}. Three previous studies have been published that assess VPA following abdominal hysterectomy\textsuperscript{43-45}. All three studies only performed measurements after surgery and compared these measurements to a non-hysterectomy group. One study, among 15 women, showed that women who had undergone hysterectomy showed lower VPA responses than women with uterine fibroids\textsuperscript{45}. The other two studies showed no difference between women after simple hysterectomy and a non-surgical group\textsuperscript{43,44}. Maas et al also included a radical hysterectomy group and found that radical hysterectomy, but not simple hysterectomy, was associated with disturbed VPA response during sexual arousal\textsuperscript{44}. Furthermore,
one small study among eight women was found to measure vaginal vasocongestion, before and after ileo pouch anal anastomosis. They also found a decrease in vaginal vasocongestion during erotic conditions. This suggests that with increasing radicality of surgery, vaginal vasocongestion is more adversely affected.

The observed decrease in vaginal wall sensibility that we detected in one of the four measured area’s after prolapse surgery, has been described previously by two studies. The first study assessed the pudendal nerve terminal motor latency before and after sacrospinous vault suspension and cystocele repair. By measuring pudendal nerve terminal motor latency, only the impact of surgery on the motor part is assessed, and not on the sensory part of the pudendal nerve. For sexual function the sensory part is thought to be of particular importance, because stimulating this sensory branch of the pudendal nerve evokes changes in vaginal vasocongestion through activation of spinal autonomic pathways, which stimulate vasodilatation and lubrication. In line with our own findings, this study showed a prolonged terminal motor latency after vaginal prolapse surgery. The other study evaluating vaginal wall sensibility after prolapse surgery, performed by our own study group, showed that vaginal prolapse surgery, as well as abdominal prolapse surgery with additional incontinence surgery, resulted in decreased vaginal wall sensibility. This decrease may be explained by the extensive vaginal wall dissection during anterior and posterior colporraphy, resulting in damage of the free nerve endings located in and near the vaginal epithelium and around the small blood vessels.

With our study we could not show an apparent impact of the changes in vaginal innervation and vasocongestion on sexual function. This contrasts the findings in male patients after non-nerve sparing radical prostatectomy, in whom regaining erectile function is not expected. Five explanations are offered that may clarify this absent relationship. The first is the small number of included women. As noted earlier, this may also be a biased sample as it is known that women willing to participate in a sexuality study have a more positive attitude towards sexuality and are more sexually active. Secondly, changes in vaginal wall sensibility may be too small to be noticed subjectively. Also, changes in vaginal wall sensibility may be relatively unimportant for sexual feelings, given that the vaginal wall seems relatively unimportant for sexual pleasure. For the latter, the clitoris is much more important. Fourthly, the FSFI may be too insensitive to pick up changes related to surgery-induced damage to the genitalia. Finally, and probably most importantly, the absence of an effect of these changes in vaginal innervation and vasocongestion on sexual function may be related to the multidimensional nature of sexual function, consisting of biological, physiological, psychological and interpersonal determinants. For example, before surgery sexual dysfunction might be caused by the pelvic organ prolapse itself, which affects psychological and interpersonal determinants such as women’s confidence and body image, whereas after surgery the procedure itself and possible damage to vaginal vasocongestion and vaginal wall sensibility might be the cause of sexual dysfunction. Changes in psychological and contextual factors are not accounted for in the used questionnaires and may well compensate for the negative effects of changes in vaginal innervation and vasocongestion. To disentangle the direct effects of surgical procedures on sexual function and indirect effects such as improved confidence, body image and symptoms relief, future studies should take the multidimensional...
nature of female sexual function into account. That can be done by careful measurement of possible variables that may mediate any negative effects on genital physiology and response, such that it is possible to calculate which pre-post changes are most significantly related to post-op differences. Only then any firm conclusion about the impact of changes in vaginal wall sensibility and vasocongestion on sexual function can be drawn.

The surgical procedure that seemed to affect vaginal vasocongestion and sensibility most, was sacrospinous fixation combined with anterior colporraphy. This might be explained by surgical disruption or trauma due to traction of the pudendal innervational and capillary bed during the dissection towards the sacro-spinous ligament\textsuperscript{18,51}. But also the lack of power in the other subgroups, might have prevented the difference between pre- and post operative vaginal vasocongestion to reach statistical significance. Future studies should continue to explore the relationship between different surgical techniques and effects on vaginal physiology. Only that insight will ultimately improve counselling of our patients and could potentially guide physicians how to improve surgical techniques in the future.

Of course, variation in the performed procedures is quite large and the number of women in the subgroups is small. This is why our findings should be interpreted cautiously. However, as no prospective studies are published that evaluated subjective as well as physiological indices of sexual function, we believe that our exploratory findings deserve a place in the literature. Of course, replication of the findings (even though such data is difficult to acquire) is essential.

**Conclusion**

In conclusion, we are the first to provide evidence that vaginal prolapse surgery negatively affects vaginal vasocongestion as well as vaginal wall sensibility in the cranial posterior vaginal wall.
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