Appl Psychophysiol Biofeedback (2015) 40:9–15
DOI 10.1007/s10484-015-9271-3

Is There Any Change in Pelvic Floor Electromyography During the First 6 Months After Radical Retropubic Prostatectomy?

Claudia R. Hacad · Howard I. Glazer · João Paulo C. Zambon · Juliana S. Burti · Fernando G. Almeida

Published online: 4 March 2015
© Springer Science+Business Media New York 2015

Abstract The aim of this study is to determine electromyographic pelvic floor muscles activity during the first 6 months post RRP and its relationship to urinary continence. Thirty-eight men (mean age of 63.1 ± 5.7 year) with prostate cancer scheduled for open radical retropubic prostatectomy were evaluated. Exclusion criteria: pelvic radiotherapy, systemic or neurologic diseases, pre-operative International Prostate Symptoms Score (IPSS) >7 and OABq ≥8. Surface electromyography (sEMG) evaluation, IPSS, Urinary Distress Inventory, Incontinence Impact Questionnaire, and Overactive Bladder Questionnaire—short form were applied before and at 1, 3, and 6 months after RRP. Six months after surgery, 18 men (47.4 %) presented urinary leakage. The sEMG evaluations within the first 6 months presented changes in fast contraction amplitude ($p = 0.006$), rest amplitude after fast contraction ($p = 0.04$), 10 s sustained contraction mean amplitude ($p = 0.024$) and final rest amplitude ($p = 0.011$). We observed that continent and incontinent patients as a group presented electromyographic changes during the first 6 months after radical prostatectomy that could be justified by the denervation/reinnervation of the external urethral sphincter. This finding is consistent with the adaptation of the pelvic floor musculature to the new urethral sphincter condition following surgery.

C. R. Hacad (✉) · J. P. C. Zambon · J. S. Burti · F. G. Almeida
Department of Urology – Female Urology and Voiding Dysfunction, Federal University of São Paulo – UNIFESP, São Paulo, Brazil
e-mail: clahacad@gmail.com

H. I. Glazer
Department of Psychiatry, Cornell University Medical College, New York, NY, USA

Keywords Radical prostatectomy · Urinary incontinence · Surface electromyography · Pelvic floor muscles

Abbreviations

EMG	Electromyography
IIQ 7	Incontinence Impact Questionnaire
IPSS	International Prostate Symptoms Score
LUTS	Lower urinary tract symptoms
OABq-SF	Overactive Bladder Questionnaire—short form
PFM	Pelvic floor muscles
RRP	Radical retropubic prostatectomy
sEMG	Surface electromyography
UDI 6	Urinary distress inventory
UI	Urinary incontinence

Introduction

Despite the important improvements in radical prostatectomy surgical techniques, urinary incontinence (UI) persists as a significant post-operative problem, with incidence ranging from 0.8 to 87 % (Bauer et al. 2009), depending on its definition. UI is a devastating symptom, frequently associated with depression, social problems and poor quality of life (Litwin et al. 1995). Most radical prostatectomy studies define UI as the presence of urinary leakage requiring the use of at least one incontinency pad per day (Rogers et al. 2006). Nonetheless, the use of pads is associated with decreased quality of life (Liss et al. 2010).

Injury to the sphincter complex during surgery is considered to be the most common cause of UI (Abrams et al. 2001). Other factors contributing to post-operative incontinence include detrusor overactivity, poor bladder compliance, small bladder capacity, dysfunction of the pelvic floor muscles (Leach et al. 1995) as well as anatomical variability on the length of the male urethral sphincter (Coakley et al. 2002).

Electromyography (EMG) has been used to evaluate neuromuscular dysfunctions (De Luca 1997). Surface electromyography (SEMG) can identify pelvic floor muscle motor unit action potentials and have shown an asymmetric distribution of innervation zones, when applied to the sphincter and puborectalis muscles (Enck and Vodusek 2006). Morphometric analysis of external anal sphincter (EAS), levator ani muscle (LAM) and puborectalis muscle has demonstrated that pelvic floor musculature is composed of slow twitch fibers (70 %) and fast twitch fibers (30 %; Gosling et al. 1983). These muscles are innervated by the pudendal nerve (Frenckner and Euler 1975) and PFM SEMG has the potential to identify these muscle fibers and nerve activity (Enck et al. 2005).

Electromyography (EMG) of the pelvic floor demonstrates changes in the motor unit activation potential during voluntary contractions, as well as minor abnormalities in the interference patterns, with increased external urethral sphincter fiber density following prostate surgery (radical retropubic prostatectomy and prostate transurethral resection; Zermann et al. 2000; Aanestad et al. 1997).

EMG may be performed using fine wire needle or surface electrodes. Classical needle EMG detects individual nerve-muscle cell damages and dysfunctions, while surface EMG offers advantages for measuring functional disorders characterized by motor unit action potentials generated from a functional group of striate muscle fibers. Recent studies have demonstrated that both types of EMG are reliable and present similar results (Pfeifer et al. 1998). Surface EMG (sEMG), by not using needles, offers the significant advantage of less discomfort and emotional distress.

In the first 6 months after radical retropubic prostatectomy (RRP) patients show a progressive improvement on continence (MacDonald et al. 2007). This suggests a progressive adaptation of pelvic floor muscles to the "new" urethral sphincter status without the bladder neck and with a shorter rabdosphincter. To better control for this factor, we designed a study using surface EMG to determine electromyographic pelvic floor muscles activity during the first 6 months post RRP and its relationship to urinary continence.

Materials and Methods

Men were voluntarily recruited from the Urology Department of the Federal University of São Paulo and submitted to a preventive prostate cancer evaluation from January of 2009 to January of 2010. Of this group, patients tested positive for prostate cancer (confirmed through prostate biopsy and anatomopathological examination) were indicated and submitted to radical prostatectomy and were invited to participate to this non-randomized trial.

Patients with previous pelvic radiotherapy, systemic or neurologic diseases that could compromise the pelvic organs and structures, with an International Prostate Symptoms Score (IPSS) greater than seven and an Overactive Bladder Questionnaire—short form (OABq) greater than eight were excluded. All patients signed a voluntary informed consent, and the study was approved by the local Ethics Committee.

Participants were evaluated before surgery and at 1, 3 and 6 months after RRP. Assessment included surface pelvic floor muscle EMG (Myotrac Infiniti with the software Biograph Infiniti—Thought Technology, Ltd., Montreal, Canada), IPSS, Urinary Distress Inventory (UDI 6), Incontinence Impact Questionnaire (IIQ 7) and OABq—SF.

sEMG Data was collected by an intra-anal longitudinal sensor (Thought Technology, Ltd., Montreal, Canada) lubricated with liquid glycerin (Fig. 1).

The reference electrode was placed on the hipbone, in order to provide grounding for differential recording (to minimize electrical artifact; Glazer et al. 1995; Hermens et al. 1998). Patients were evaluated in the supine and semi reclined position, with semi flexion of the knees and external rotation of the heels while stretching the internal obturator muscle, in order to improve pelvic floor sEMG readings (Glazer and MacConkey 1996).

Pelvic floor muscle surface electromyography has been used to evaluate myoelectric characteristics, as the signal amplitude and variability, spectral frequency of the signal, the activation and deactivation time of motor units action potentials of muscle fibers (Basmajian e De Luca, 1985).

The amplitude is related to motor units activity, i.e., to the level of recruitment and discharge of active motor units. The spectral frequency of sEMG signal is used to assess the recruitment changes of the motor units, estimating the activation of the muscle fibers type I and II during a contraction. The activation time is the interval between rest and maximal voluntary contraction observed in sEMG signal, and deactivation time is the interval between maximal voluntary contraction and rest.

We can observe in rest amplitude the high level of recruitment and discharge of active motor units during rest, showing that patients with urinary incontinence could increase unconsciously the muscle fiber activity to avoid urinary leakage.

Figure 1 shows the placement of SEMG sensor.

Procedures followed a previously described validated protocol (Glazer et al. 1995, 1999). Signal amplitude, variability, power density median spectral frequency, and activation/deactivation time values of pelvic floor muscle fibers were measured using a voluntary sequence of pelvic floor muscles contractions and relaxations, as follows:

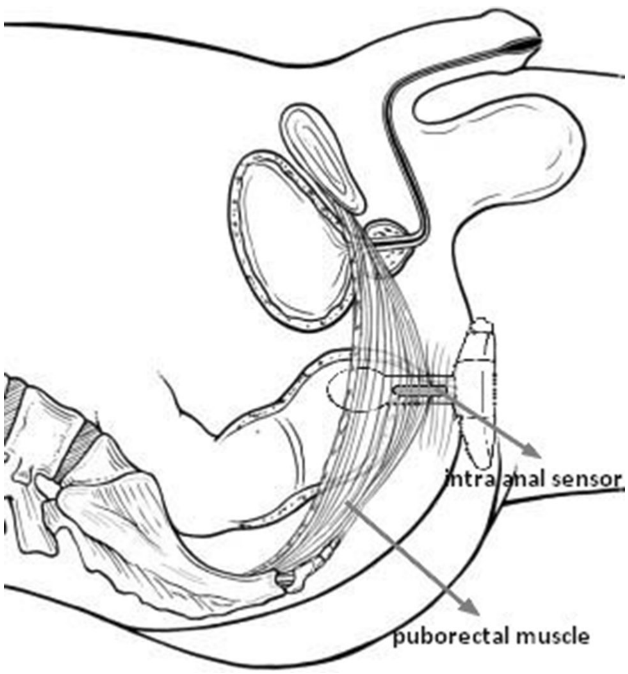

Fig. 1 Placement of sEMG intra anal sensor

- Initial pre-baseline rest (60 s of initial rest).
- Phasic contractions (five fast contractions of 1 s with 10 s rest intervals).
- Tonic contractions (five sustained contractions lasting 10 s, with 10 s rest intervals).
- Endurance contraction (60 s of sustained contraction).
- Final post-baseline rest (60 s of final rest).

Figure 2 illustrates the assessment protocol.

To better characterize our population and describe the results, two definitions were used to assess UI 6 months following prostatectomy:

1. Patients using any pad or positive answer (>0) in question 4 of UDI-6 (Liss et al. 2010).

    Do you experience small amounts of urine leakage?
    0. No, does not occur
    1. Yes, does not bother me
    2. Yes, bothers me slightly
    3. Yes, bothers me moderately
    4. Yes, bothers me greatly

2. Patients using more than one pad per day (Rogers et al. 2006).

Patients were divided in two groups: continent and incontinent. To perform the analysis, patients were classified as continent when reporting that they were not using any pad and answering "0" in the question 4 of UDI-6.

Variables were analyzed descriptively. Quantitative variables were analyzed using minimum and maximum pelvic floor muscles sEMG values, and summarized by mean, median and standard deviation values. For qualitative variables (self-reported questionnaires), absolute and relative frequencies were calculated. The Student *t* test (1) (Rosner 1986) was used to compare the mean values of two groups. When the hypothesis of normal distribution of the data was rejected, the Mann–Whitney test was used (Rosner 1986). In order to analyze for group differences, analyses of variance with repeated measures (ANOVA; Timm 1975) was used.

In order to analyze if there are symptoms (via the application of self-reported questionnaires scores) and if there are pelvic floor sEMG variables prior to surgery that could predict UI 6 months after being submitted to surgery, predictive factors were estimated using multivariate linear regression model (Rosner 1986). Statistical significance was defined as $p < 0.05$.

Results

We evaluated 40 patients without any lower urinary tract symptoms pre operatively at the hospital, a week before the surgery. Of this group, two patients refused to participate in the assessments at 1, 3 and 6 months after surgery. Thirty eight patients (mean age = 63.1 ± 5.7 years) completed the study.

Demographic data are presented in Table 1.

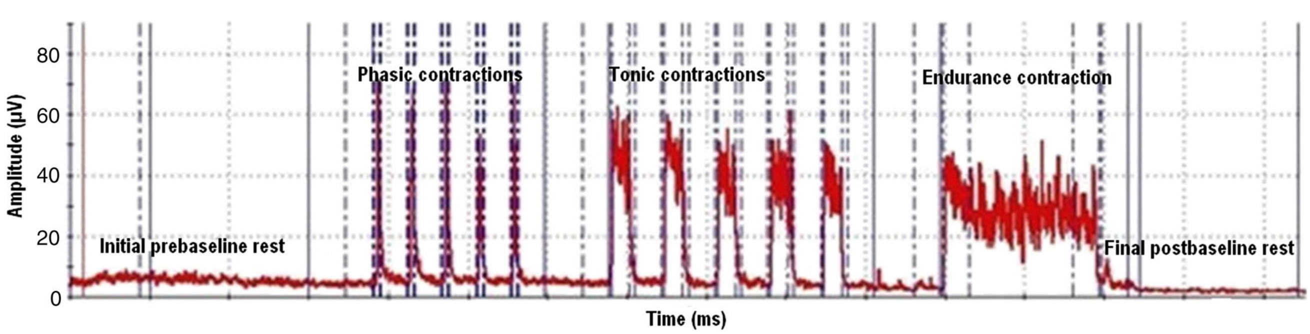

Fig. 2 sEMG intrapelvic assessment

We observed that continent and incontinent patients as a group presented a significant increase in fast contraction maximum amplitude ($p = 0.006$) and 10 s sustained contraction mean amplitude ($p = 0.024$) within the 6 months. Rest amplitude after fast contraction ($p = 0.04$) and final rest mean amplitude ($p = 0.011$) increased after 1 month of surgery and then decreased thereafter.

Table 2 shows PFM SEMG variables before surgery and 1, 3, 6 months after RRP.

We have described the percentage of patients with UI, 6 months after surgery, using the two different definitions and the analysis of patients with and without UI: when UI was defined as using more than one pad/day, 10 (26.3 %) patients were incontinent and 28 (73.7 %) were completely dry. When UI is defined as any leakage, 18 (47.4 %) patients were incontinent and 20 (52.6 %) were completely dry. Regardless of the UI definition we did not find any difference in sEMG data among themselves.

Six months after prostatectomy, those patients considered continent (completely dry) were compared to incontinent patients (reporting that they were using any pad and positive answer in question 4 of UDI-6) regard their preoperative sEMG data (Tables 3, 4).

No significant correlations were found between sEMG variables before surgery and the self-reported questionnaires scores (UDI, IIQ, OAB and IPSS) 6-months after surgery.

Table 1 Demographic data ($n = 38$)

Variable	Value
Age (mean ± SD)	63.13 ± 5.71
Educational—*n* (%)	
Secondary	30 (78.9 %)
High school	8 (21.1 %)
Hypertension	19 (50.0 %)
Diabetes	2 (5.3 %)
Heart diseases	3 (7.9 %)
Throat cancer	1 (2.6 %)
Depression	1 (2.6 %)
Tumor stage	
pT1	13 (34.22 %)
pT2	15 (39.47 %)
pT3	10 (26.31 %)

Discussion

This is the first study combining lower urinary tract subjective measures obtained from questionnaires with objective clinical measures (pads/day) and electrophysiological data from pelvic floor sEMG to evaluate progressive changes in pelvic floor muscles during the first 6 months post RRP.

Preoperative sEMG did not differ between patients that would become continent or incontinent 6 months post RRP, independent of the UI definition. Furthermore, continent and incontinent patients as a group presented significant changes in fast contraction amplitude and 10 s sustained contraction mean amplitude within the 6 months following RRP.

Both rest amplitude variables went up at 1 month, indicating that just after surgery all patients submitted to prostatectomy undergo to an adaptation of the pelvic floor musculature to the new urethral condition following surgery, i.e., the external urethral sphincter increased the muscle fibers activation in absence to the internal urethral sphincter. Patients with urinary incontinence may increase unconsciously the muscle fiber activity to avoid urinary leakage. In 3 and 6 months, we noticed that the rest amplitude values went down, showing a decrease of the level of recruitment and discharge of active motor units.

Our data suggests a pelvic floor progressive post-surgical adaptation with increased recruitment of fast twitch fibers regardless of continent status. It is also possible that all patients underwent sEMG assessment for several times (pre, 1, 3 and 6 months post RRP) "learned" to recruit external urethral sphincter muscle.

Table 2 sEMG variables at pre, 1, 3 and 6 months ($n = 38$)

sEMG variables	Preoperative Mean (SD)	1 month Mean (SD)	3 months Mean (SD)	6 months Mean (SD)	*p*
Activation time fast contraction (ms)	2.05 (0.30)	1.95 (0.39)	2.12 (0.30)	1.94 (0.37)	0.485
Activation time 10 s sustained contraction (ms)	2.07 (1.84)	1.86 (0.64)	1.98 (0.54)	1.99 (0.57)	0.599
Activation time 60 s sustained contraction (ms)	1.42 (0.59)	1.34 (0.62)	1.59 (0.56)	1.59 (0.69)	0.637
Fast contraction amplitude (μV)	59.66 (34.39)	61.39 (28.10)	65.34 (25.55)	75.26 (32.18)	0.006
Rest amplitude after fast contraction (μV)	11.01 (7.82)	15.09 (12.62)	14.32 (8.72)	13.37 (6.70)	0.04
10 s sustained contraction amplitude (μV)	32.12 (17.90)	38.28 (22.01)	39.64 (18.08)	40.26 (17.23)	0.024
60 s sustained contraction amplitude (μV)	35.73 (84.39)	25.47 (15.42)	26.32 (18.86)	25.56 (16.06)	0.94
Final rest amplitude (μV)	7.13 (9.09)	8.81 (8.23)	6.97 (3.78)	6.38 (3.56)	0.011

Table 3 Longitudinal sEMG changes within continent and incontinent groups

sEMG variables	Preoperative Mean (SD)	1 month Mean (SD)	3 months Mean (SD)	6 months Mean (SD)	*p*
Continent (n = 20)					
Activation time fast contraction (ms)	2.06 (0.18)	1.93 (0.29)	2.08 (0.32)	1.99 (0.32)	0.804
Activation time 10 s sustained contraction (ms)	1.83 (0.80)	1.90 (0.80)	1.89 (0.62)	1.81 (0.57)	0.624
Activation time 60 s sustained contraction (ms)	1.36 (0.52)	1.25 (0.49)	1.50 (0.64)	1.41 (0.77)	0.608
Fast contraction amplitude (μV)	64.76 (33.47)	68.57 (29.91)	66.51 (27.13)	82.05 (32.08)	0.076
Rest amplitude after fast contraction (μV)	11.85 (9.59)	17.53 (14.36)	12.79 (7.35)	14.05 (7.81)	0.009
10 s sustained contraction amplitude (μV)	33.23 (16.81)	44.47 (24.36)	38.30 (18.59)	41.30 (17.28)	0.276
60 s sustained contraction amplitude (μV)	47.52 (115.82)	28.39 (16.37)	25.76 (19.52)	22.80 (9.02)	0.675
Final rest amplitude (μV)	6.51 (4.90)	10.69 (10.51)	6.69 (3.86)	7.21 (4.00)	0.021
Incontinent (n = 18)					
Activation time fast contraction (ms)	2.04 (0.40)	1.97 (0.49)	2.17 (0.27)	1.90 (0.42)	0.476
Activation time 10 s sustained contraction (ms)	1.68 (0.44)	1.82 (0.43)	2.08 (0.44)	2.18 (0.52)	0.022
Activation time 60 s sustained contraction (ms)	1.48 (0.67)	1.43 (0.74)	1.70 (0.46)	1.76 (0.57)	0.532
Fast contraction amplitude (μV)	53.99 (35.46)	53.80 (24.62)	64.11 (24.48)	68.46 (31.70)	0.066
Rest amplitude after fast contraction (μV)	10.08 (5.34)	12.51 (10.25)	15.94 (9.92)	12.69 (5.53)	0.172
10 s sustained contraction amplitude (μV)	30.88 (19.45)	31.76 (17.60)	41.06 (17.96)	39.22 (17.82)	0.066
60 s sustained contraction amplitude (μV)	22.64 (12.69)	22.40 (14.15)	26.92 (18.69)	28.33 (20.81)	0.706
Final rest amplitude (μV)	7.81 (12.34)	6.84 (4.30)	7.28 (3.77)	5.55 (2.93)	0.076

Table 4 Comparative analysis between continent and incontinent groups

sEMG variables	Continent ($n = 20$)	Incontinent ($n = 18$)	*p*
Preoperative RRP			
Fast contraction amplitude (μV)	64.76 (33.47)	53.99 (35.46)	0.342
Rest amplitude after fast contraction (μV)	11.85 (9.59)	10.08 (5.34)	0.494
Activation time fast contraction (ms)	2.08 (0.16)	2.01 (0.41)	0.507
Activation time 10 s sustained contraction (ms)	1.83 (0.80)	1.68 (0.44)	0.488
Activation time 60 s sustained contraction (ms)	1.35 (0.53)	1.57 (0.57)	0.229
10 s sustained contraction amplitude (μV)	33.23 (16.81)	30.88 (19.45)	0.691
60 s sustained contraction amplitude (μV)	47.52 (115.82)	22.64 (12.69)	0.371
Final rest amplitude (μV)	6.51 (4.90)	7.81 (12.34)	0.667
6 months post RRP			
Fast contraction amplitude (μV)	82.05 (32.08)	68.46 (31.70)	0.198
Rest amplitude after fast contraction (μV)	14.05 (7.81)	12.69 (5.53)	0.543
Activation time fast contraction (ms)	1.99 (0.33)	1.88 (0.43)	0.379
Activation time 10 s sustained contraction (ms)	1.81 (0.57)	2.18 (0.52)	0.045
Activation time 60 s sustained contraction (ms)	1.59 (0.61)	1.78 (0.58)	0.369
10 s sustained contraction amplitude (μV)	41.30 (17.28)	39.22 (17.82)	0.717
60 s sustained contraction amplitude (μV)	22.80 (9.02)	28.33 (20.81)	0.137
Final rest amplitude (μV)	7.21 (4.00)	5.55 (2.93)	0.157

The incidence of post prostatectomy UI ranges from 0.8 to 87 % depending on the definition (Bauer et al. 2009). Determining the best definition for UI is challenging. Furthermore, large case-series failed to evaluate preoperative continence status, as well as presence of lower urinary tract symptoms (LUTS). Male urinary incontinence has a tremendous impact on patient's quality of life (Litwin et al. 1995). Clinically, identifying the patients most likely to present UI after prostatectomy is a great challenge that could impact on strategic therapeutic decisions. Since people respond differently to UI, we believe that assessment should consider not only the number of pads, but also self-perception of UI impact. Liss et al. (2010) analyzed 500 patients submitted to post-robotic prostatectomy using questionnaires and also counting pads/day. They found that the impact on quality of life was the same even in those men who efficiently used pads, including the definition of continence as no pad use.

We carefully assessed patient's symptoms to include only those without significant LUTS to avoid biases (assessing symptoms not related to the surgical procedure). Furthermore, we evaluated the data using two different UI definitions and patients self-reported use of pad. Independent of the UI definition (any urinary leakage or greater than one pad a day) we could not find any difference in sEMG data. Based on our results, continence status post RRP is not related to the pre-operative pelvic floor sEMG and the sEMG does not predict which patient would become incontinent after surgery. We observed pelvic floor sEMG changes after surgery that occurs in both continent and incontinent patients. Radical prostatectomy did not damage the pelvic floor muscles (MacDonald et al. 2007; Goode et al. 2011) or their innervations (Catarin et al. 2008). It has been suggested that continence following well-performed RRPs is associated with the length of the urethral sphincter. Magnetic resonance imaging supports that continence following RRP is correlated with urethral sphincter's length (Coakley et al. 2002) and that surgery predisposes to sensitive autonomic afferent denervation on the membranous urethra, but does not impact the pudendal innervations (Catarin et al. 2008). The changes in sEMG observed in our study, suggests that changing the sphincter mechanism by removing the prostate and bladder neck generates pelvic floor adaptations, such as increasing tonus and voluntary contraction amplitude in continent and incontinent patients as a group at 6 months post RRP. Our data support those of Aanestad et al. (1997) who evaluated 20 patients using EMG needle electrodes, and found an increase in external urethral sphincter fiber density in the absence of internal urethral sphincter muscle fibers, following surgery.

The pelvic floor adaptations seem to be similar in continent and incontinent patients, suggesting that the continence may be mainly associated with the remaining rabdosphincter muscle rather than any pelvic floor disorder. Since the urethral rabdosphincter and pelvic floor muscles have similar roots' innervation and the EMG pelvic floor response to RRP was similar in continent and incontinent patients, urethral changes after RRP may be triggered by a pudendal response that modify the sEMG readings. It may be associated with a reflex response of the status of the new urethra. In addition, the pelvic floor adaptations occurring in the first 6 months after surgery would help to understand the increase in continence rate in such period of time.

Zermann et al. (2000) demonstrated that the activation pattern between the resting intervals and those periods of maximal voluntary contraction change immediately following surgery, with decreased firing of motor units.

Similarly, we found a significant slower activation time on 10 s sustained contraction in incontinent patients 6 month post RRP, but this was not seen on fast or 60 s sustained contractions.

A negative aspect of this study is the limited sample sizes of the two groups and it would be induced in misleading conclusions.

UI following RRP may reflect several potential pathophysiological factors. Even patients without previous LUTS or bladder problems may experience UI after technically well-performed surgeries. Patients did not receive any physiotherapy intervention and after 6 months 47 % still presented urinary leakage. The urologists of the Department were informed by the authors not to give instructions about PFM exercises within the first 6 months. All physiotherapists and urologists involved in this study informed the patients about possible changes of the continence status during these months. After this period, they were instructed by a specialized physiotherapist how to perform pelvic floor muscle exercises.

Studies with the association of anatomical and functional evaluation may help to better predict, understand and treat post prostatectomy UI.

Conclusions

We observed that continent and incontinent patients as a group presented electromyographic changes during the first 6 months after radical prostatectomy that could be justified by denervation/reinnervation of the external urethral sphincter. This finding is consistent with the adaptation of the pelvic floor musculature to the new urethral sphincter condition following surgery.

Acknowledgments The authors thank Prof. Dr. Gilberto M. Manzano for his valuable assistance during the development of the study.

References

Aanestad, O., Flynk, R., & Norlén, B. J. (1997). Interference pattern in perineal muscles: A quantitative electromyographic study in patients before and after transurethral surgery of the prostate. *Neurourology and Urodynamics, 16*, 101–109.

Abrams, P., Cardozo, L., & Wein, A. (2001). The international consultation on incontinence, research society (ICI-RS). *Neurourology and Urodynamics, 29*, 596–597.

Bauer, R. M., Bastian, P. J., Gozzi, C., & Stief, C. G. (2009). Post prostatectomy incontinence: All about diagnosis and management. *European Urology, 55*, 322–333.

Catarin, M. V., Manzano, G. M., Nobrega, J. A., et al. (2008). The role of membranous urethral afferent autonomic innervation in the continence mechanism after nerve sparing radical prostatectomy: A clinical and prospective study. *Journal of Urology, 180*, 2527–2531.

Coakley, F. V., Eberhardt, S., Kattan, M. W., et al. (2002). Urinary continence after radical retropubic prostatectomy: Relationship with membranous urethral length on preoperative endorectal magnetic resonance imaging. *Journal of Urology, 168*, 1032–1035.

De Luca, C. J. (1997). The use of electromyography in biomechanics. *Journal of Applied Biomechanics, 13*(2), 135–163.

Enck, P., Hinninghofen, H., Merletti, R., et al. (2005). The external sphincter and the role of surface electromyography. *Neurogastroenterology and Motility, 17*(Suppl. 1), 60–67.

Enck, P., & Vodusek, D. (2006). Electromyography of pelvic floor muscles. *Journal of Electromyography and Kinesiology, 16*(6), 568–577.

Frenckner, B., & Euler, C. V. (1975). Influence of pudendal block on the function of anal sphincters. *Gut, 16*(6), 482–489.

Glazer, H. I., & MacConkey, D. (1996). Functional rehabilitation of pelvic floor muscles: A challenge to tradition. *Urologic Nursing, 16*, 68–69.

Glazer, H. I., Rodke, G., Swencionis, C., et al. (1995). Treatment of vulvar vestibulitis syndrome with electromyographic biofeedback of pelvic floor musculature. *Journal of Reproductive Medicine, 40*, 283–290.

Glazer, H. I., Romanzi, L., & Polaneczky, M. (1999). Pelvic floor muscle surface electromyography; reliability and clinical predictive validity. *Journal of Reproductive Medicine, 44*, 779–782.

Goode, P. S., Burgio, K. L., Johnson, T. M., I. I., et al. (2011). Behavioral therapy with or without biofeedback and pelvic floor electrical stimulation for persistent post prostatectomy incontinence: A randomized controlled trial. *JAMA, 305*, 151–159.

Gosling, J. A., Dixon, J. S., & Humpherson, J. R. (1983). *Functional anatomy of the urinary tract. An integrated text and colour atlas*. London: Gower Medical Publishing.

Hermens, H. J., Rau, G., Disselhorst-Klug, C., & Freriks, B. (1998). *Surface ElectroMyoGraphy application areas and parameters—SENIAM 3*. Aachen: Roessingh Research and Development.

Leach, G. E., Chi-Ming, Y., & Donovan, Bj. (1995). Post-prostatectomy incontinence: The importance of bladder dysfunction. *Journal of Urology, 153*, 1038.

Liss, M. A., Osann, K., Canvasser, N., et al. (2010). Continence definition after radical prostatectomy using urinary quality of life: Evaluation of patient reported validated questionnaires. *Journal of Urology, 183*, 1464–1468.

Litwin, M. S., Hays, R. D., Fink, A., et al. (1995). Quality of life outcomes in men treated for localized prostate cancer. *JAMA, 273*, 129–135.

MacDonald, R., Fink, H. A., Huckabay, C., et al. (2007). Pelvic floor muscle training to improve urinary incontinence after radical prostatectomy: A systematic review of effectiveness. *BJU International, 101*, 76–81.

Pfeifer, J., Teoh, T. A., Salanga, V. D., et al. (1998). Comparative study between intra-anal sponge and needle electrode for electromyographic evaluation of constipated patients. *Diseases of the Colon and Rectum, 41*, 1153–1157.

Rogers, C. G., Su, L. M., Link, R. E., et al. (2006). Age stratified functional outcomes after laparoscopic radical prostatectomy. *Journal of Urology, 176*, 2448–2452.

Rosner, B. (1986). *Fundamentals of Biostatistics* (2nd ed.). Boston: Duxubury Press.

Timm, N. H. (1975). *Multivariate analysis with applications in educations and psychology*. Monterrey, CA: Brooks/Cole Pub. Co.

Zermann, D. H., Ishigooka, M., Wunderlich, H., et al. (2000). A study of pelvic floor function pre and post radical prostatectomy using clinical neurological investigations, urodynamics and electromyography. *European Urology, 37*, 72–78.