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Quantifying Pelvic Floor Muscle Recovery After Robotic-Assisted Radical Prostatectomy: Insights from Electromyography and Perineometer Readings

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Abstract

Introduction: Robotic-assisted radical prostatectomy (RRP) is an advanced treatment for localized prostate cancer, but postoperative urinary incontinence remains a concern, affecting quality of life. This study aims to objectively quantify pelvic floor muscle (PFM) recovery after RRP using electromyography (EMG) and perineometer measurements.

Materials and Methods: A prospective study was conducted on 48 men who underwent RRP between October 2022 and October 2023. Participants performed pelvic floor exercises pre- and post-surgery. EMG and perineometer assessments were taken preoperatively, at catheter removal, and three months postoperatively. Manual muscle testing (MMT) and statistical analysis, including Mc Nemar-Bowker and Friedman tests, were used to assess changes over time.

Results: At three months post-RRP, significant improvements ($p<0.05$) in MMT, perineometer quick contraction, contraction hold, and resting penile tone were observed. EMG revealed an initial decline in muscle activity, followed by a marked recovery at 3 months follow up. Significant decline in anal ring muscle activity were also noted.

Conclusion: EMG and perineometer readings demonstrated significant PFM recovery post-RRP, highlighting the effectiveness of pelvic floor exercises. Developing objective metrics for PFM recovery could improve postoperative care and guide rehabilitation protocols. Further research is necessary to validate these findings across larger cohorts.

Keywords: Robotic Urology, Pelvic Floor, Incontinence, Radical Prostatectomy

Introduction

Radical prostatectomy remains the gold standard treatment for patients with localized prostate cancer [1]. In recent years, the number of radical prostatectomies performed has significantly increased, largely due to advancements in minimally invasive surgical techniques, particularly robotic-assisted approaches [2]. Despite these technical innovations, urinary incontinence continues to affect 9-16% of patients following radical prostatectomy, which can significantly impact quality of life [3].

The etiology of post-prostatectomy urinary incontinence is multifactorial, with impaired function of the pelvic floor muscles (PFM) recognized as a key contributor [4]. PFM consist of both slow-twitch (~70%) and fast-twitch (~30%) muscle fibers [5]. These fibers play an essential role in maintaining pelvic tone and providing structural support to pelvic organs, particularly during rest and during sudden increases in intra-abdominal pressure. This support mechanism is critical for ensuring adequate urethral closure pressure under stress, thereby preventing incontinence [6].

Given the increasing prevalence of radical prostatectomy, particularly robotic-assisted radical prostatectomy (RRP) and the interest in nerve preservation procedures to enhance the quality of lives of the patients, there is a need for a comprehensive understanding of the associated changes in pelvic floor muscle strength [7]. Electromyography (EMG) and perineometry provide valuable tools for assessing these changes. However, there is a lack of objective metrics that document muscle activity and its potential recovery following pelvic floor rehabilitation post-RRP [8].

The aim of this study is to evaluate the alterations in pelvic floor muscle strength induced by RRP through the use of EMG and perineometer assessments. Furthermore, this study seeks to establish an innovative metric for documenting muscle activity in patients undergoing RRP and to assess the effectiveness of pelvic floor exercises in improving these parameters.

Materials and Methods

Men scheduled for robotic-assisted radical prostatectomy (RRP) for carcinoma of the prostate were recruited for this prospective, non-randomized study between October 2022 and October 2023. Patients with a history of prior pelvic radiotherapy or neurological conditions were deemed ineligible for participation. All participants provided voluntary informed consent, and the study received clearance from institutional ethics committee (AMH-C-S-010/01-24).

Before surgery, all eligible participants were instructed pelvic floor muscle (PFM) exercises. They were advised to perform these exercises (100 repetitions/day) daily until the day of surgery, with reinforcement provided on the day of catheter removal. None of the patients underwent nerve sparing procedure in this cohort. Postoperatively, patients were instructed to continue the exercises for an additional 3 months.

PFM evaluation was conducted at three time points: preoperatively, at the time of catheter removal, and 3 months after RRP. Assessments included EMG using the INTELECT® NEO Therapy System (Enovis™, USA) with surface electrodes placed at the anus, base of the penis, and perineum, as well as perineometer readings using the PERITRON™ (Technomed Systems, India). To further evaluate improvements in pelvic tone, manual muscle testing (MMT) was performed via digital rectal examination, utilizing the modified Oxford scale methodology.

Statistical Analysis

Descriptive statistics were presented as frequency (percentage) for categorical variables and as mean ± standard deviation (SD) for continuous variables. When the data were skewed, the median (interquartile range, IQR) was reported. The Mc Nemar-Bowker test was used to assess significant changes between pre-operative and post-operative visits. The Friedman test was applied to determine significant differences over time. A p-value of < 0.05 was considered statistically significant. All statistical analyses were performed using SPSS (IBM, version 28.0).

Results

The demographic details of the study cohort (n=48) are described in Table 1. The staging (T and N stage) of the disease, Gleason grading based on final histopathological diagnosis, and metastatic staging as per PSMA PET scan are also tabulated in Table 1. 79.2% had lower urinary tract symptoms of at least mild severity, as determined by the IPSS score.

MMT readings (Table 2) showed significant improvement at the third-month follow-up ($p<0.05$), with all measurements performed by the same physician. Significant changes ($p<0.05$) were observed in perineometer measurements for quick contraction, contraction hold, and resting penile tone when compared to preoperative values, with assessments taken at one week postoperatively and at the three-month follow-up.

Penile quick contraction increased at the time of catheter removal (one week postoperatively) and at the three-month follow-up; however, the levels decreased from preoperative values, although this change was not statistically significant. A similar trend was observed in penile contraction hold.

Resting perineal tone decreased from preoperative levels at the time of catheter removal and at the three-month follow-up, whereas perineal quick contraction decreased at one week postoperatively and showed a marginal increase nearing preoperative levels by the third-month follow-up. Perineal contraction hold followed a similar pattern to perineal quick contraction.

Anal resting tone significantly decreased ($p<0.05$) at the three-month follow-up. This significant decline was also observed in anal ring quick contraction and anal ring contraction hold.

Table 1: Demographic Factors

Parameters	n = 48 (%)
Age in years	
Mean ± SD	64.7 ± 6.7
Range	47 – 74
40 – 50	2 (4.2)
51 – 60	8 (16.7)
61 – 70	28 (58.3)
71 – 80	10 (20.8)
BMI	
Mean ± SD	24.8 ± 2.9
Range	17.9 – 31.8

Comorbidity	
Yes	36 (75)
No	12 (25)
Staging	
T2	27 (56.2)
T3	20 (41.7)
T4	1 (2.1)
N	
0	39 (81.25)
1	9 (18.8)
M	
0	46 (95.8)
1	2 (4.2)
LUTS	
Yes	38 (79.2)
No	10 (20.8)
Gleason Grading	
G-I	9 (18.8)
G-II	10 (20.8)
G-III	8 (16.7)
G-IV	16 (33.3)
G-V	5 (10.4)

Table 2: MMT Readings at Various Time Periods

EMG	Time period, (n=48)			P-value**
	Pre-operative	Catheter Removal	3 months post RRP	
Grade-I	-	-	-	
Grade-II	-	-	-	
Grade-III	4 (8.4)	11 (22.9)	-	0.043
Grade-IV	17 (35.4)	9 (18.7)	3 (6.3)	
Grade-V	27 (56.3)	28 (58.3)	45 (93.8)	

^^- McNemar's-Bowker test between pre-operative and 3rd month post-operative visit; Boldface indicates statistical significance

Table 3: EMG Readings at Various Time Periods

EMG	Time period, (n=48)			P-value**
	Pre-operative	Catheter Removal	3 months post RRP	
Perineometer quick contraction				
Mean ± SD	120.9 ± 51.3	98.9 ± 39.2	149.5 ± 48.8	<0.001
Range	42 – 244	54 – 206	62 – 292	
Perineometer contraction hold				
Mean ± SD	114.9 ± 51.5	100.7 ± 35.9	143.5 ± 58.9	<0.001
Range	38 – 225	59 – 117	10 – 291	
Penis resting tone				
Mean ± SD	73.7 ± 75.8	93.6 ± 75.5	49.4 ± 42.1	0.048
Median (IQR)	46.5 (20.5 – 102.5)	86 (29.7 – 121.5)	27 (21 – 69)	
Range	6 – 279	4 – 321	7 – 232	
Penis quick contraction				
Mean ± SD	95.8 ± 79.2	102.4 ± 78.6	78.7 ± 45.5	0.834
Median (IQR)	69 (41.3 – 125.3)	97 (37.3 – 127)	65 (41 – 101)	

Range	13 – 309	14 – 342	26 – 257	
Penis contraction hold				
Mean ± SD	94.9 ± 79.2	98.8 ± 80.6	77.9 ± 45.8	0.727
Median (IQR)	67 (38.7 – 126.5)	79.5 (36 – 128.3)	64 (41 – 102)	
Range	14 – 310	10 – 353	27 – 258	
Perineum resting tone				
Mean ± SD	54.1 ± 59.3	44.9 ± 34.4	44 ± 56.8	0.084
Median (IQR)	33 (19.3 –56.8)	37 (17.5 – 80.5)	23 (10.5 – 46.3)	
Range	5 – 288	4 – 103	5 – 290	
Perineum quick contraction				
Mean ± SD	74 ± 63.4	56.5 ± 37.1	70.1 ± 60.7	0.867
Median (IQR)	55.5 (3.8 – 91)	46.5 (25.3 – 95)	44.5 (34 – 86.5)	
Range	19 – 299	7 – 121	19 – 324	
Perineum contraction hold				
Mean ± SD	75.9 ± 65.4	54.1 ± 38.9	71.1 ± 63.6	0.446
Median (IQR)	57 (32 – 81.5)	39.5 (25.7 – 97)	47 (31.3 – 90.5)	
Range	18 – 314	7 – 120	10 – 320	
Anal ring resting tone				
Mean ± SD	74.3 ± 71.8	69.9 ± 77.6	24.4 ± 28	0.012
Median (IQR)	52.5 (17.3 – 110.5)	36 (21 – 96)	12 (9 – 29)	
Range	4 – 302	4 – 320	5 – 159	
Anal ring quick contraction				
Mean ± SD	106.7 ± 80.8	81.4 ± 78.8	51.2 ± 35.5	0.002
Median (IQR)	84 (37.5 – 161.3)	48 (32 – 111)	37 (31.3 – 51.7)	
Range	10 – 321	14 – 336	16 – 207	
Anal ring contraction hold				
Mean ± SD	106.3 ± 77.8	84.2 ± 78.6	49.3 ± 28.4	0.003
Median (IQR)	82 (41.5 – 155)	57 (32.5 – 118)	39 (34 – 51.8)	
Range	11 – 319	14 – 340	16 – 156	

**- Friedman test; Boldface indicates statistical significance

Discussion

Urinary incontinence is a common and predictable consequence in men with localized prostate cancer who have undergone radical prostatectomy [9]. Despite advancements in surgical techniques, the recovery time for urinary continence remains highly variable [10]. Numerous surgical and patient-related risk factors for post-prostatectomy urinary incontinence have been identified, including age, body mass index (BMI), membranous urethral length, and urethral sphincter insufficiency [11]. Physical activity interventions that incorporate aerobic exercise, resistance training, and pelvic floor muscle training (PFMT) programs have been shown to positively influence the return to continence in men after radical prostatectomy [12]. Comprehensive interventions that integrate these exercise programs starting in the preoperative period (prehabilitation) and continuing postoperatively are essential for regaining continence.

While these prehabilitation and rehabilitation protocols are recommended globally, the grading and objective measurement of the outcomes from these programs have not been standardized. This gap hinders the ability of both patients and physicians to gauge whether the pelvic floor muscle training is being performed correctly. Many patients are unaware of how to properly contract the pelvic floor muscles, resulting in the loss of critical time needed for optimal recovery from urinary incontinence [13]. Moreover, the availability of medical staff to guide and supervise the rehabilitation process is insufficient in many parts of the world [14]. Therefore, it is essential to develop methods that quantify the efforts made by patients during their training programs. Objectifying these efforts through measurable metrics can help identify patients who have not correctly understood PFMT techniques and allow healthcare providers to deliver additional, targeted care. Moreover, these metrics could help predict which patients are likely to recover continence once favorable values are achieved and validated across larger, multi-center studies.

In a review by Mungovan et al., transperineal ultrasonography was described as a non-invasive and validated method for visualizing the action of the pelvic floor muscles, providing real-time visual biofeedback to patients during PFMT.However, this approach can be observer-dependent, which may introduce variability in the results. Zheng-Zheng Ma et al. developed a pelvic floor muscle rehabilitation training program for post-prostatectomy patients through two rounds of expert consultation [15]. Their study divided Kegel exercises and pelvic floor muscle rehabilitation into two levels based on exercise intensity. The program emphasized patient positioning and exercise duration, and considered various factors such as home-based training in settings where healthcare providers are limited. Despite the detailed nature of their program, the study lacked a metric-based grading system to assess the outcomes of the exercise regimen.

Similarly, in the MaTchUP randomized controlled trial by Paul Hodges et al., 363 participants were randomized into urethral training, conventional training, and no training groups [16]. Neuromuscular control of the pelvic floor muscles was measured at baseline, postsurgery, 6 weeks, 3 months, and 12 months. However, the study relied on subjective metrics such as pad usage, questionnaires, and healthcare costs related to incontinence. Implementing an objective metric assessment could provide a more standardized approach to validate outcomes and enhance the ability to conduct uniform meta-analyses in future studies.

In a study by Szczygielska et al., the effectiveness of PFMT in men post-radical prostatectomy was enhanced by the inclusion of EMG biofeedback, which appeared to increase the effectiveness of therapy [17]. This study involved three groups of patients with varied training durations, with only one group receiving biofeedback. The findings highlight the importance of biofeedback in reinforcing proper exercise techniques in patients. However, the study did not employ objective metrics and was limited to a small cohort of 40 patients. Similarly, Burgio et al., in their randomized controlled trial, emphasized the value of biofeedback in rehabilitation [18].

Our study utilized objective measurements, including EMG at various pelvic floor locations and perineometer readings, to evaluate pelvic floor muscle activity after RRP. The perineometer readings indicated a reduction in perineal pressure immediately after RRP, followed by a substantial increase at the three-month follow-up. These findings correlated with the MMT scores obtained by the same physician.19 EMG recordings at the base of the penis demonstrated increased muscle fiber activity immediately after RRP, potentially due to compensatory efforts by the patient to prevent urine leakage. This overactivity returned to baseline by three months, correlating with the perineometer readings.

Conversely, EMG recordings at the perineum and anal ring showed weakened muscle activity and decreased external anal sphincter (EAS) pressures, in contrast to perineometer readings, which showed marked improvement. Further research is required to explore this discrepancy and to determine whether surface muscle activity contributes to continence.

Significant improvements in MMT values at three months suggest that PFMT plays a crucial role in urinary incontinence recovery following RRP. Our study provides an objective evaluation of the impact of RRP on the pelvic floor muscles and offers insights into the recovery of muscle function with PFMT.

A limitation of our study is the lack of a comparative arm, as all patients were advised to perform pelvic floor exercises per institutional protocol. Additionally, since this is an initial evaluation focused on objective measurements, potential confounders could not be identified or controlled. The results were compared only with MMT scores, not with pad usage, as the primary aim was to develop metrics and formulate hypotheses for future comparative studies and randomized controlled trials.

Conclusion

This study objectively assessed the effects of robotic-assisted radical prostatectomy (RRP) on pelvic floor muscle function and the role of pelvic floor muscle training (PFMT) in urinary continence recovery. EMG and perineometer measurements demonstrated significant improvements in muscle function at the three-month follow-up, indicating that PFMT, initiated preoperatively and continued postoperatively, is crucial for enhancing continence recovery. Developing objective metrics to assess PFMT effectiveness could help identify patients needing additional guidance, improve rehabilitation strategies, and provide uniformity in future studies. Further research is needed to validate these metrics and better understand their relationship to continence outcomes across larger, multi-center studies.

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