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**Authors**

Suskind, Anne M
DeLancey, John OL
Hussain, Hero K
et al.

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# Dynamic MRI evaluation of urethral hypermobility post radical prostatectomy

**Anne M. Suskind**[1], **John O. L. DeLancey**[2], **Hero K. Hussain**[3], **Jeffrey S. Montgomery**[1], **Jerilyn M. Latini**[4], and **Anne P. Cameron**[1]

[1]University of Michigan, Department of Urology

[2]University of Michigan, Department of Obstetrics and Gynecology

[3]University of Michigan, Department of Radiology

[4]Alaska Native Medical Center, Department of Urology and Adjunct faculty at the University of Michigan, Department of Urology

## Abstract

**Aims—**One postulated cause of post prostatectomy incontinence is urethral and bladder neck hypermobility. The objective of this study was to determine the magnitude of anatomical differences of urethral and bladder neck position at rest and with valsalva in continent and incontinent men post prostatectomy based on dynamic MRI.

**Methods—**All subjects underwent a dynamic MRI protocol with valsalva and non-valsalva images and a standard urodynamic evaluation. MRI measurements were taken at rest and with valsalva, including (1) bladder neck to sacrococcygeal inferior pubic point line (SCIPP), (2) urethra to pubis, and (3) bulbar urethra to SCIPP. Data were analyzed in SAS using two–tailed t tests.

**Results—**A total of 21 subjects (13 incontinent and 8 continent) had complete data and were included in the final analysis. The two groups had similar demographic characteristics. On MRI, there were no statistically significant differences in anatomic position of the bladder neck or urethra either at rest or with valsalva. The amount of hypermobility ranged from 0.8mm to 2mm in all measures. There were also no differences in the amount of hypermobility (position at rest minus position at valsalva) between groups.

**Conclusions—**We found no statistically significant differences in bladder neck and urethral position or mobility on dynamic MRI evaluation between continent and incontinent men status post radical prostatectomy. A more complex mechanism for post prostatectomy incontinence needs to be modeled in order to better understand the continence mechanism in this select group of men.

## Introduction

Over 200,000 men are diagnosed with prostate cancer each year,(1) almost half of whom will choose to undergo radical prostatectomy as their primary form of treatment.(2) Because deaths from prostate cancer are on the decline, most men are living long past their diagnosis and greatly suffer from the unintended consequences of their treatment. Up to 75% of men experience some form of post-prostatectomy urinary incontinence (PPI),(3) which has been shown to significantly negatively impact their quality of life.(4)

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Corresponding Author: Anne M. Suskind, MD Department of Urology Building 520, 3rd Floor 2800 Plymouth Road Ann Arbor, MI 48109 (734) 647-6402 suskina@med.umich.edu.

Despite being a common and important problem, little is known about the mechanism of PPI. Several competing hypotheses exist;(5-7) however, there is no consensus on the anatomy of the structures believed to be integral to continence.(8-10) One such hypothesis suggests that this condition is caused by urethral and bladder neck hypermobility due to the absence of the prostate and its fascial and ligamentous structures.(11, 12)

In order to address this knowledge gap, we designed a pilot study using dynamic MRI evaluation of continent and incontinent men post prostatectomy. We expected to find a greater amount of urethral hypermobility in incontinent men compared to continent men. Findings from this study will potentially help to clarify the anatomic role of the bladder neck and urethra in the development of PPI.

## Materials and Methods

### Study participants

This is a case control study designed to look at anatomic differences between continent and incontinent men post radical prostatectomy. After approval from the medical institutional review board, men who underwent prostatectomy from 1997 to 2011 were recruited from the general urologic, urologic oncology, and male incontinence clinics at our institution.

Participants were eligible to enroll in the study if (1) they underwent a retropubic or laparoscopic (robotic) radical prostatectomy at least 12 months prior to starting the study, and (2) they had not had any surgical treatment for urinary incontinence (including an artificial urinary sphincter, male sling, or any type of injectable agent). Cases were comprised of men who met the above criteria and who had stress urinary incontinence based on self-reported history and demonstration of urine loss on 24 hour pad weights. Controls were comprised of men who met the above criteria and did not report any amount of urinary leakage and did not wear any pads. Exclusion criteria included the presence of urge urinary incontinence, urinary retention, neurologic disease, high dose steroid use, pre-surgical abnormal voiding function or incontinence, prior pelvic radiation, current medical therapy for incontinence, perineal route of radical prostatectomy, pelvic recurrence of prostate cancer, and the presence of any relative or absolute contraindications to MRI such as implants or claustrophobia.

### Study protocol

Once consented, patients underwent a pre-study screening with a general medical history, and a focused urologic physical examination by one of the study urologists. Additionally, incontinent subjects submitted a 24 hour pad collection for the calculation of pad weights and all men completed the AUA Symptom Index. All subjects underwent multichannel urodynamics performed by a trained urodynamics nurse using standardized methods to rule out detrusor overactivity as the cause of urinary incontinence. Urodynamics were performed with the subject in the standing position using an 8F dual microtip urodynamics catheter and a fill rate of 50cc/min with normal saline. Rectal pressure was measured via a rectal balloon catheter filled with saline. All pressure transducers were zeroed to atmospheric pressure at the level of the bladder and all urodynamic definitions complied with the standardized terminology of the International Continence Society.(13)

Magnetic resonance images (MRI) evaluation was performed on all subjects in the supine position using a 3.0 Tesla Model Philips Achieva, Philips Medical Systems MRI unit. Images were obtained depicting 2mm slices with T1-weighted and fast spin echo T2-weighted sequences of the pelvis in the axial, sagittal, and coronal views.(14, 15) MRI sequences were performed at rest and at maximum valsalva effort(16) without the use of intravenous contrast or an endorectal coil.

### MRI measurements

MRI measurements were adapted from those previously identified and performed in women (reference).(17, 18) Measurements were performed in the midsagital plane using T2-weighted sequences both at rest and at maximum valsalva. Measurements were obtained in reference to the sacrococcygeal to inferior pubis (SCIPP) line, which is a well-established reference line that extends from the posterior surface of the pubis to the junction between the fifth sacral and first coccygeal bone (Figure 1).(17-20) In order to measure points on the urethra distal to the pubis, we simply extended the SCIPP line. Three measurements were then taken in reference to the SCIPP line: the first measurement was taken as a perpendicular line from the SCIPP line to the bladder neck, shown as point B; the second measurement was taken as a perpendicular line from the area on the SCIPP line that corresponded to the inferior portion of the pubis to the urethra, point C; the final measurement was taken from the SCIPP line to the widest part of the bulbar urethra, point D. Figure 2 shows an example of the anatomic structures in a single subject at rest and with valsalva, in reference to the SCIPP line.

### Statistical analysis

Two urologists (APC and AMS) independently measured and recorded the various MRI measurements using eFilm Workstation software version 3.4.0 (2010 Merge Healthcare). Large discrepancies between reviewer measurements (>5 mm) were identified and re-measured. Inaccurate initial measurements were replaced with more accurate ones where appropriate. Each reviewer's measurements were then averaged for each measurement point. The averaged values were then used in the final statistical analysis. The difference between rest and valsalva measurements was simply the subtracted value of the two.

Comparisons between cases and controls and demographic characteristics and measurements were made using simple t tests and Fisher's Exacts tests where appropriate. Analyses were performed with SAS version 9.3 (SAS Institute, Cary, NC). The probability of a Type I error was set at 0.05 and all testing was 2-sided.

## Results

The final analysis consisted of a total of 21 subjects, 13 cases and 8 controls. No subjects had detrusor overactivity on urodynamic testing. Mean age was 68.2 years (±6.4) among cases and 65.7 years (±6.2) among controls (p=0.40). The cases had a mean pad weight of 428.6 grams (range 8.0 to 1,823.0 grams) and a mean AUA Symptom Index score of 13 (± 8.0) compared to 3 (±2.0) in controls. There were no statistically significant differences in demographic characteristics between groups in terms BMI, race, type of prostatectomy, time since prostatectomy, PSA, or Gleason score (Table I).

Table II depicts the MRI measurements at rest, at maximum valsalva, and the difference between these two states. Of note, there were no statistically significant differences in anatomic position of the bladder neck or urethra either at rest or with valsalva. The amount of hypermobility ranged from only 0.8 mm to 2.0 mm in all measures. There were also no differences in the amount of hypermobility (position at rest minus position at valsalva) between groups. Interestingly, cases tended to have a shorter distance between the bladder neck and the SCIPP line compared to controls, measuring 0.4 (±0.6) cm compared to 1.0 (±1.2) cm at rest and 0.5 (±0.6) cm and 1.2 (±0.9) cm with valsalva, respectively. This trend; however, was not statistically significant either at rest or with valsalva, (p=0.23) and (p=0.05), respectively. In order to determine whether the surgical approach (open versus laparoscopic/robotic) affected our measurements, we performed a similar analysis stratified by surgical approach. Results were consistent with our previous unstratified analysis.

## Discussion

Continent and incontinent men status post radical prostatectomy showed no statistically significant differences in anatomic measurements of the urethra and bladder neck on dynamic MRI evaluation, regardless of surgical approach. Additionally, neither group showed strong evidence of urethral hypermobility, which has previously been postulated to be a potential cause of post-prostatectomy incontinence.

DeLancey originally investigated anatomic determinants of urethral support in female cadavers. From this work, he determined that increases in urethral closure pressure during valsalva arise because the urethra is compressed against a hammock-like supportive layer.(21) This “hammock hypothesis” was then applied to male PPI, and became the theoretical basis of Rehder and Gozzi's transobturator sling suspension. Also based on cadaveric dissection, Rehder and Gozzi hypothesized that relocation of the posterior urethra into a more proximal position without disturbing the sphincter mechanism would potentially help to overcome male urinary incontinence. In other words, they felt that fixation of the urethral hypermobility via a sling would result in restoration of continence in men with PPI.(12)

Soljanik and colleagues evaluated 26 men who underwent transobturator sling suspensions with functional MRI to determine the anatomic changes associated with this procedure. They observed significant elevation of the posterior bladder wall, bladder neck, and external urinary sphincter after sling placement, as expected. However, the authors found that sling failure was more likely to be related to the severity of pre- and post-operative periurethral fibrosis than to the anatomic location of these structures.(22)

While examination of periurethral fibrosis was outside the scope of this study, our findings are consistent with those of Soljanik and colleagues in that we did not find any statistically significant urethral hypermobility with maximum valsalva among post-prostatectomy men either with or without urinary incontinence, suggesting that mechanisms other than urethral hypermobility warrant exploration.

While we did not find any statistically significant evidence of urethral hypermobility on dynamic MRI evaluation, our results did indicate that continent men tended to have a larger distance between the bladder neck and the SCIPP line compared to incontinent men. This finding; however, was not statistically significant, as the study was not sufficiently powered to detect this difference.

Of note, our study did not find any differential outcomes based on the surgical approach that was used (i.e. open versus laparoscopic/robotic). Another study reported similar findings when evaluating the MRI appearance of structures post prostatectomy.(15) Taken collectively these data support the idea that type of prostatectomy does not significantly affect MRI appearance of anatomic structures or whether or not the patient is incontinent post surgery.

Our findings should be interpreted with certain limitations in mind. First, it is important to recognize that these data represent a pilot study of 21 men. While we recognize that this represents a small sample size, we do believe that it is a good starting point to further our understanding of anatomic principles regarding PPI. Additionally, this small sample size limited our ability to further evaluate subgroups within our study population. Again, as a pilot study, our goal was to determine whether any stark differences existed between the cases and controls, not to explore differences between specific groups.

In the future we plan to address other hypotheses for PPI with more focused measurement of periurethral fibrosis, urethral length, and pelvic floor musculature. We will also correlate these findings with results of urodynamic testing in order to get a better understanding of the functional components of PPI.

## Conclusions

There were no statistically significant differences in bladder neck and urethral position on dynamic MRI evaluation at rest and with valsalva between continent and incontinent men after radical prostatectomy. The amount of hypermobility in these structures was also not different between groups and was very small. A more complex mechanism for post prostatectomy incontinence needs to be modeled in order to better understand the continence mechanism in this select group of men.

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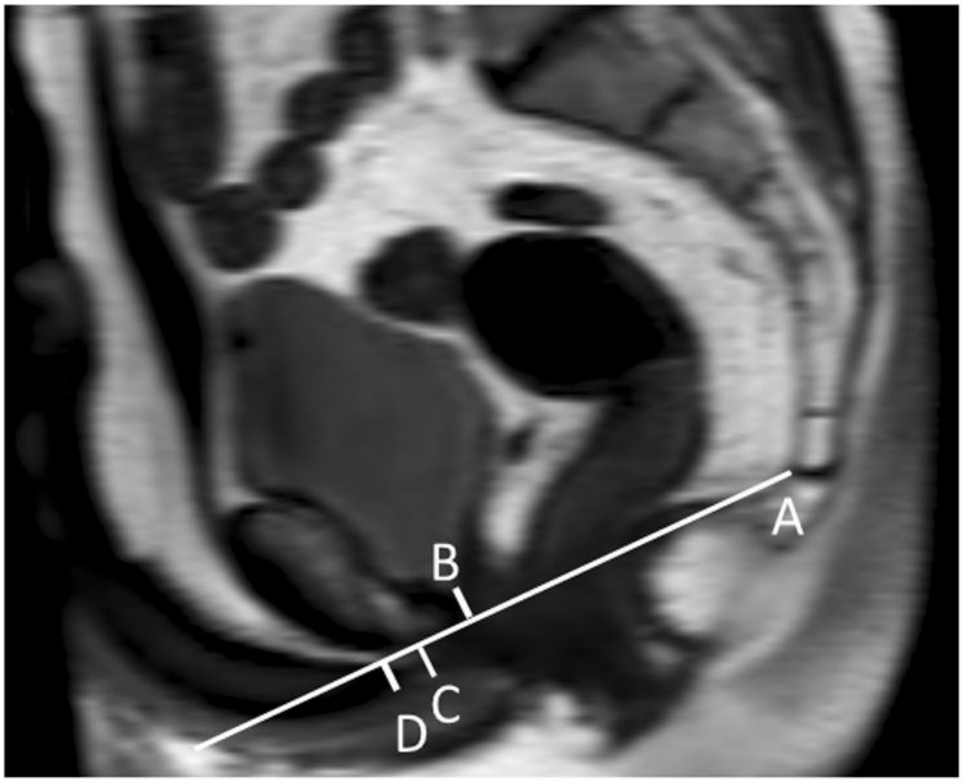

**Figure 1.**
Sagittal pelvic magnetic resonance image (MRI) illustrating (A) the SCIPP line, (B) the distance from the bladder neck to the SCIPP line, (C) the distance from the inferior pubis to the urethra, and (D) the distance from the SCIPP line to the widest part of the bulbar urethra.

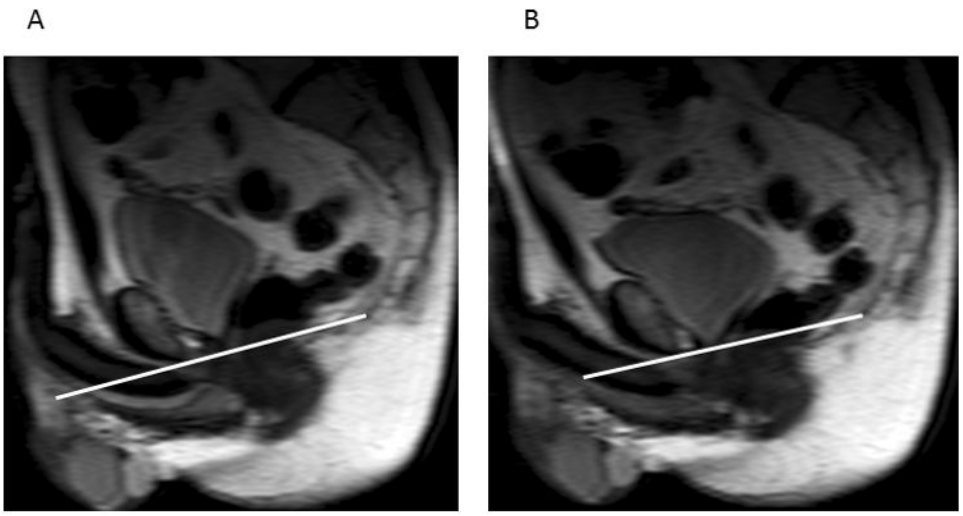

**Figure 2.**
Sagittal pelvic magnetic resonance image (MRI) illustrating the anatomic structures in a single subject at rest (A) and with valsalva (B), with reference to the SCIPP line.

## Table I

Demographic and cancer characteristics of cases and controls.

| | Cases | Controls | P-value |
|---|---|---|---|
| Number | 13 | 8 | |
| Age in years (mean, SD) | 68.2 (±6.4) | 65.7 (±6.2) | 0.40 |
| BMI (mean, SD) | 27.3 (±7.3) | 29.2(±2.8) | 0.50 |
| Race (%) | | | |
| White | 84.6 | 87.5 | 1.00 |
| Non-White | 15.4 | 12.5 | |
| Type of Prostatectomy (%) | | | |
| Open | 53.9 | 37.5 | 0.66 |
| Robotic | 46.2 | 62.5 | |
| Time since prostatectomy in years (mean, SD) | 4.6 (±4.1) | 5.2 (±4.0) | 0.74 |
| PSA prior to prostatectomy (mean, SD) | 7.7 (±4.9) | 5.4 (±3.7) | 0.29 |
| Gleason score (mean, SD) | 6.7 (±0.7) | 6.9 (±0.4) | 0.49 |
| Pad weight in g/24hr (mean, range) | 428.6 (8.0-1823.0) | NA | NA |
| AUA Symptom Index score (mean, SD) | 13 (±8.0) | 3 (±2.0) | <0.01 |

## Table II

Comparison of various MRI measurements between cases and controls. *Measurements are in cm.*

| | **Cases** | **Controls** | **P-value** |
|---|---|---|---|
| At rest | | | |
| Bladder neck to SCIPP line | 0.4 (± 0.6) | 1.0 (± 1.2) | 0.23 |
| Pubis to urethra | −1.1 (± 0.3) | −1.0 (± 0.4) | 0.50 |
| SCIPP to bulbar urethra | −1.3 (± 0.2) | −1.0 (± 0.5) | 0.11 |
| At maximal valsalva | | | |
| Bladder neck to SCIPP line | 0.5 (± 0.6) | 1.2 (± 0.9) | 0.05 |
| Pubis to urethra | −1.3 (± 0.4) | −1.2 (± 0.4) | 0.70 |
| SCIPP to bulbar urethra | −1.4 (± 0.3) | −1.1 (± 0.4) | 0.09 |
| Difference | | | |
| Bladder neck to SCIPP line | 0.08 (± 0.6) | 0.2 (± 0.8) | 0.83 |
| Pubis to urethra | 0.2 (± 0.3) | 0.2 (± 0.1) | 0.83 |
| SCIPP to bulbar urethra | 0.1 (± 0.2) | 0.2 (± 0.2) | 0.61 |