

Do pelvic dimensions and prostate location contribute to the risk of experiencing complications after radical prostatectomy?

Christian von Bodman^{*,†}, Kazuhito Matsushita^{*}, Mika P. Matikainen^{*}, James A. Eastham^{*}, Peter T. Scardino^{*}, Oguz Akin[†] and Farhang Rabbani[§]

^{*}Urology Service, Department of Surgery, and [†]Department of Radiology, Memorial Sloan-Kettering Cancer Center, New York, [§]Department of Urology, Montefiore Medical Center, Bronx, NY, USA, and [†]Department of Urology, University Clinic Bochum, Marienhospital Herne, Herne, Germany

Accepted for publication 29 November 2010

Study Type – Therapy (case series)
Level of Evidence 4

OBJECTIVE

- To assess if pelvic size, such as a narrow, steep pelvis, as well as prostate location in relation to the pelvic anatomy might have an impact on the likelihood of experiencing complications after radical prostatectomy.

PATIENTS AND METHODS

- In a standardized manner, different bony and soft tissue dimensions on preoperative staging MRI were retrospectively measured in a study cohort of 934 patients undergoing radical prostatectomy. Measurements were defined aimed at assessing pelvic size and prostate location.
- Medical and surgical complications after radical prostatectomy were meticulously reviewed and grouped into subcategories to assess whether a narrow, steep pelvis and an anatomically deeply situated prostate (which is thought to be more surgically challenging) might be associated with a higher likelihood of postoperative complications.
- Multivariate Cox regression was performed to assess if dimensions have a significant impact on the likelihood of postoperative complications.

RESULTS

- While known parameters such as a higher preoperative PSA and presence of

What's known on the subject? and What does the study add?

Surgical complications are more commonly observed in older patients, men with a greater BMI, higher pretreatment PSA greater ASA score, and those who have a longer operative duration. In rectal cancer surgery and prostate cancer surgery, reports suggest that patients with a smaller pelvic size had a higher likelihood of having a positive surgical margin, assumedly due to a more challenging operation in an anatomically narrower pelvis. Whether complication rates are impacted by pelvic size and prostate location has not been investigated yet. To the best of our knowledge our study investigates the largest cohort to date where pelvic bony and soft tissue dimensions were measured on preoperative prostate MRI and correlated with medical and surgical complications to assess if these anatomical factors might impact or predict the development of medical or surgical complications.

Anatomical factors that might contribute to the likelihood of developing complications after radical prostatectomy should be identified to adjust and optimize prostate cancer surgery. Preoperative MRI of the prostate and pelvis provides an optimal tool to measure pelvic size and prostate dimensions, as well as prostate location which might be associated with the development of complications after radical prostatectomy. Whether unfavorable anatomy such as a narrow and steep pelvis or a deeply-situated prostate might lead to a technically more demanding operation, being associated with a higher probability of postoperative complications, remains unclear. Our data suggests that anatomical variation of the pelvis and prostate location do not significantly impact surgical technique in regard to the risk of developing complications after radical prostatectomy in the hand of experienced surgeons.

comorbidities were associated with an increased risk of experiencing complications after surgical treatment, none of the dimensions assessed on preoperative MRI had a significant impact on the development of any medical or surgical complication.

CONCLUSION

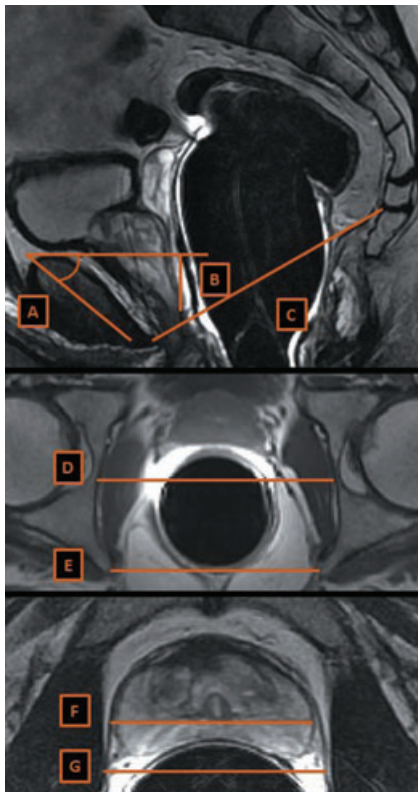
- We report the largest cohort of patients where pelvic dimensions were evaluated in a

standardized manner on preoperative MRI aimed at assessing anatomic factors and their impact on complications after radical prostatectomy. None of the measurements could significantly predict the likelihood of developing medical or surgical complications.

KEYWORDS

prostate cancer, radical prostatectomy complications, MRI, pelvic dimensions

FIG. 1. (A) Symphysis angle defined as angle between the long axis of the symphysis pubis and the horizontal (mid-sagittal T2-weighted images). (B) Depth of prostate defined as orthogonal distance from top of symphysis pubis to apex of prostate (mid-sagittal T2-weighted images). (C) The anteroposterior diameter of pelvic midplane was defined as distance from lower inner symphysis pubis to sacrococcygeal junction (mid-sagittal T2-weighted image). (D) The bony width of the pelvis at the mid-femoral head level (axial T1-weighted image). (E) Interspinous distance defined as distance between the tips of the ischial spines (axial T1-weighted images). (F) Prostate width defined as maximal width of the prostate (Axial T2-weighted image). (G) Soft tissue width defined as narrowest distance between the levator muscles (axial T2-weighted image).



INTRODUCTION

Surgical complications are more commonly seen in older patients, those with a greater body mass index, higher pretreatment PSA, greater American Society of Anesthesiology score, larger prostate size or those with a longer operative duration [1]. Anatomic factors that might contribute to the likelihood of developing complications after radical prostatectomy should be identified

to adjust and optimize prostate cancer surgery. Preoperative MRI of the prostate and pelvis provides an optimal tool to determine different soft tissue and bony measurements to determine if pelvic dimensions and prostate size and location might be associated with the development of complications after radical prostatectomy.

Whether unfavourable anatomy, such as a narrow, steep pelvis or a deeply situated prostate, might lead to a technically more demanding operation, being associated with a higher probability of postoperative complications, remains unclear. In rectal cancer surgery, it was reported that patients with a smaller pelvic size had a higher likelihood of having a positive surgical margin (PSM), probably because of a more challenging operation in an anatomically narrower pelvis [2]. Anthropological studies document that the pelvis is narrower and smaller in African American men [3]. We have previously reported that ethnicity was found to be a significant independent predictor of apical PSM with African American men having a higher apical PSM rate [4]. Hypothesizing that a narrower pelvis might be one factor among others leading to a technically more challenging operation we subsequently evaluated pelvimetric dimensions on MRI. Apical depth of the prostate was identified to be a significant independent predictor of apical PSM with a more pronounced effect in African American men [5]. Based on this background, we sought to measure different pelvic soft tissue and bony dimensions to determine whether anatomy might impact on the likelihood of experiencing medical or surgical complications in patients undergoing radical prostatectomy.

PATIENTS AND METHODS

In our prospective prostatectomy database, after institutional review board approval was obtained, we identified 934 men with preoperative prostate MRI undergoing radical prostatectomy, either open or laparoscopic (LRP), without neoadjuvant androgen deprivation therapy between January 2002 and December 2004 by one of three dedicated prostate surgeons. Data were collected from a prospective prostatectomy database together with a prospective institutional morbidity database as well as retrospectively from all postoperative inpatient and outpatient billing

records, inpatient and outpatient medical records including physician notes, operative notes, discharge summaries, nursing notes and correspondence with local physicians outside our institution. All complications other than erectile dysfunction and incontinence, both medical and surgical, occurring at any time after surgery were captured including both the inpatient stay and the outpatient setting. All complications were recorded with a grade (I, II, IIIa, IIIb, IVa, IVb or V) assigned according to the modified Clavien classification and were grouped into subcategories of medical and surgical complications [6]. Median follow up was 45.5 months (interquartile range 32.1–55.2 months). Specimen weight was recorded at the time of pathological examination and included the prostate, seminal vesicles and vasa deferentia stumps. We evaluated different pelvic bony and soft tissue measurements as well as prostate depth on preoperative MRI images (Fig. 1).

The MRI studies were performed on a 1.5-Tesla system (Signa; GE Medical Systems, Milwaukee, WI, USA). A body coil for excitation and a pelvic phased-array coil (GE Medical Systems) in combination with an endorectal coil (Medrad, Pittsburgh, PA, USA) for signal reception were used. Transverse spin-echo T1-weighted images were obtained through the pelvis with the following parameters: repetition time/echo time 400–600 ms/8–10 ms; section thickness 5 mm; intersection gap 1 mm; field of view 24 cm; matrix 256 ± 192 ; and two signals were acquired. Thin-section, high-spatial-resolution transverse, coronal, and sagittal T2-weighted fast spin-echo images were obtained through the prostate and the seminal vesicles with the following parameters: repetition time/echo time 4000–6000 ms/96–120 ms; echo train length 12–16; section thickness 3 mm; intersection gap 0 mm; field of view, 12–14 cm; matrix 256×192 ; and four signals acquired. Automated correction was applied to the T1- and T2-weighted images for the reception profile of the endorectal and pelvic phased-array coils. Bony measurements were made of the pelvic inlet and midplane as well as soft tissue measurements at the pelvic midplane and prostate measurements, expressed in mm. All measurements were defined by an experienced radiologist. Training was performed under supervision and the accuracy of the measurements was confirmed by the radiologist.

The symphysis angle was defined as the angle between the long axis of the symphysis pubis and the horizontal on the mid-sagittal T2-weighted sequence image (Fig. 1A). The apical depth of the prostate was defined as the craniocaudal distance (in mm) from the most proximal margin of the symphysis pubis to the level of the distal margin of the prostatic apex as measured on the mid-sagittal T2-weighted sequence image (Fig. 1B). The interspinous distance (ISD) was measured as the distance (in mm) between the ischial spines on the axial T1-weighted sequence image (Fig. 1E). The pelvic dimension index was as defined by Hong *et al.* [7] as the ISD divided by apical depth. The bony femoral width of the pelvis at the mid-femoral head level (BFW) was measured in mm on the axial T1-weighted sequence image (Fig. 1D). Given that the BFW is measured at a more anterior plane corresponding to the location of the prostate than the ISD, the BFW may be more representative of the width of the bony pelvis encountered by the urologist when performing radical prostatectomy. The bony width index was defined as BFW divided by apical depth. Maximal prostate width (Fig. 1F) and the soft tissue width, defined as the narrowest distance in mm between the levator muscles, were measured on the axial T2-weighted sequence images (Fig. 1G). The soft tissue width index was defined as the soft tissue width divided by apical depth. The mid-pelvic area in cm² was calculated by the formula for an ellipse: $\pi \times \text{anteroposterior diameter defined as distance from the lower inner symphysis pubis to the sacrococcygeal junction (Fig. 1C) (in mm)} \times \text{BFW (in mm)} / 400$.

We analysed independent predictors for medical and surgical complications as well as high-grade (grade III–V) medical and surgical complications using multivariate Cox proportional hazards methods. We included patient age, ethnicity, body mass index, comorbidities, modified Charlson score, specimen weight, surgeon, PSA, stage and Gleason score as well as ISD, apical depth, pelvic dimension index, BFW, soft tissue width, mid-pelvic area and symphysis angle as co-variables. The modified Charlson score predicts the 10-year survival for a patient with a number of comorbid conditions, taking into account the presence of 19 diseases, weighted on the basis of their association with mortality with the modified score also accounting for patient age [6]. Statistical analyses were performed using the SPSS

statistical package (SPSS Inc., Chicago, IL, USA).

RESULTS

Radical prostatectomy was performed in 934 patients who had preoperative MRI by one of three dedicated prostate surgeons. In all, 627 (67%) men were treated with radical prostatectomy and 307 (33%) patients with LRP. Median patient age was 59.2 (interquartile range: 54.4, 64.1). Table 1 summarizes the clinical, radiographic and pathological parameters in the total cohort of 934 patients. A total of 267 complications were observed and stratified into medical ($n = 109$) and surgical ($n = 158$) complications. These were subgrouped into seven categories shown in Table 2. With regard to medical complications, infections (50%) were the most common, followed by gastrointestinal (15%) and cardiac (14%) complications. Most surgical complications were urological ($n = 64$; 41%). Stratifying these 64 urological complications in detail, urinary retention (36%) was the most common, followed by urinoma (31%), bladder neck contracture (25%) and hydronephrosis (8%). Nineteen lymphocoeles (12%) were observed in the lymphovascular category and two (1%) rectal injuries were reported in the surgical gastrointestinal complications. The Cox proportional hazards regression models for prediction of medical and surgical complications incorporating various pelvimetric measures are presented in Table 3. In the multivariate analysis a higher PSA, laparoscopic approach, presence of vascular comorbidities, and a higher modified Charlson score were associated with a higher risk of medical or surgical complications. None of the bony or soft tissue pelvic dimensions were significant predictors for the likelihood of experiencing medical or surgical complications. With respect to high-grade medical or surgical complications (grade III–V modified Clavien classification), pelvimetric dimensions were not significantly associated with the likelihood of experiencing high-grade complications.

DISCUSSION

Studies using standardized reporting criteria for complications have shown that medical or surgical complications occur in approximately 10–25% of patients treated with open,

conventional laparoscopic or robot-assisted radical prostatectomy for prostate cancer [1,8,9]. Despite the fact that most complications are minor, factors that might impact the risk of complications should be evaluated to optimize treatment and minimize complication rates. Age, pretreatment PSA, modified Charlson score, body mass index and surgeon volume among other factors, have been previously reported to independently predict the risk of complications [1,8,9]. Whether pelvic anatomy plays a role in the occurrence of complications or whether surgeon technique can compensate for a more challenging operation in a steep or narrow pelvis remains unknown.

Pelvic MRI is more frequently used mainly for staging purposes in prostate cancer patients before surgery. This technique provides excellent axial and sagittal images of the pelvic anatomy allowing the measurement of bony and soft tissue dimensions in a standardized manner. In this study, we aimed to investigate if pelvic dimensions or location of the prostate in relation to the pelvis might have an impact on the risk of complications. We did not aim to implement pelvic MRI measurements as a standard preoperative planning procedure but rather to use this valuable source to improve our understanding of anatomy and its potential impact on complication rates in a more objective, scientific way. Boyle *et al.* [2] suggested that pelvic size assessed on preoperative MRI may importantly impact the difficulty of surgical procedure in colorectal surgery. Hong *et al.* [7,10] reported that pelvic dimensions might have some impact, although not a significant impact, on difficulty of open and robot-assisted radical prostatectomy. Based upon a limited number of cases, including 190 and 141 men, respectively, both studies are underpowered but suggest that further investigation of this hypothesis is warranted. Recently Mason *et al.* [11] reported that a narrow, deep pelvis may predict a more difficult procedure, based upon a longer operative time and an increased blood loss. His study cohort included only 76 patients treated with robot-assisted radical prostatectomy. This finding might be limited because of the low number of patients investigated in the study by Mason *et al.* [11]. The learning curve of the surgeon and a higher number of patients investigated might change the results of this pilot study. Other reports suggest that anatomy does not effect

TABLE 1 Clinical, radiographic and pathologic parameters

Parameter	Patients (N = 934)
Age (years): median (IQR)	59.2 (54.4–64.1)
BMI (kg/m ²): median (IQR)*	27.2 (25.2–29.8)
Ethnicity: n (%)	
Caucasian	840 (89.9)
African-American	44 (4.7)
Other/unknown	50 (5.4)
Clinical stage: n (%)	
T ₁	577 (61.8)
T ₂	326 (34.9)
T ₃	31 (3.3)
Biopsy Gleason score: n (%)	
2–6	565 (60.5)
7	312 (33.4)
8–10	57 (6.1)
Preoperative PSA (ng/ml): median (IQR)	5.4 (4.1–7.5)
Nerves preserved†: n (%)	
0	29 (3.2)
0.5	12 (1.3)
1	62 (6.7)
1.5	96 (10.4)
2	720 (78.3)
Surgeon: n (%)	
Surgeon 1	304 (32.5)
Surgeon 2	307 (32.9)
Surgeon 3	323 (34.6)
Radical prostatectomy approach: n (%)	
Open	627 (67.1)
Laparoscopic	307 (32.9)
Modified Charlson score: n (%)	
0	93 (10.0)
1	351 (37.6)
2	344 (36.8)
3	115 (12.3)
4	22 (2.4)
≥5	9 (1.0)
Diabetes, n (%)	61 (6.5)
Cardiac comorbidity, n (%)	66 (7.1)
Vascular comorbidity, n (%)	73 (7.8)
Interspinous distance (mm): median (IQR)	93 (88–98)
Apical depth (mm): median (IQR)	27 (22–32)
Symphysis angle: median (IQR)	40.7 (37.5–44.0)
Pelvic dimension index: median (IQR)	3.42 (2.88–4.27)
Mid-pelvic area: median (IQR)	82.9 (76.9–89.8)
Mid-pelvic area index: median (IQR)	3.11 (2.58–3.88)
Bony femoral width (mm): median (IQR)	102.5 (98–107)
Bony femoral width index: median (IQR)	3.79 (3.19–4.72)
Soft tissue width (mm): median (IQR)	55 (51–59)
Soft tissue width index: median (IQR)	2.04 (1.70–2.53)
Anteroposterior diameter of pelvic midplane (mm): median (IQR)	103 (97–110)
Prostate width: median (IQR)	47 (44–51.5)
Pathological stage: n (%)	
pT ₀	4 (0.4)
pT ₂	664 (71.1)
pT ₃	252 (27.0)
pT ₄	14 (1.5)

outcomes in larger robotic prostatectomy series [10]. Previously we reported that patients with a prostate deeper in the pelvis had a higher risk of having a positive surgical margin, speculating that the anatomical location of the prostate in relation to the pelvis may impact the difficulty of prostate cancer surgery [5,12].

In an attempt to investigate the impact of pelvic dimensions on complications we performed standardized measurements on preoperative MRI in almost 1000 patients. We did not find a significant correlation between pelvic dimensions and the risk of developing medical or surgical complications. Stratifying into high-grade and low-grade complications, the evaluated pelvic bony and soft tissue dimensions were not significantly associated with the risk of experiencing any grade of complication. Factors such as a narrow and deep pelvis as well as a prostate situated deep in the pelvis have been suggested to be associated with a more challenging surgical procedure, which might lead to an adverse outcome [7,12]. In our study, these factors were not found to be predictive for postoperative complications. The subgroup of patients treated in the LRP group in our study had a higher risk of experiencing medical complications on multivariate analysis. Generally there are more comorbidities in the LRP group because those with potential cardiac disease may have leaned toward LRP because of less blood loss being involved with this technique. Hence, they may still have a higher medical complication rate, despite adjusting for Charlson score on the multivariate analysis. We believe that most probably, surgeon technique did compensate for anatomical variation even in anatomically more challenging cases. Most surgeons do subjectively experience different surgical cases as more or less challenging. We carefully evaluated complications in detail but did not find a significant impact of pelvic anatomy on complication rates. This might be different for other outcomes (e.g. incontinence). Generally there are more comorbidities in the LRP group because those with potential cardiac disease may have leaned toward LRP due to less blood loss. Hence, they may still have a higher medical complication rate, despite adjusting for Charlson score on the multivariate analysis.

All surgeons in our study are experienced high-volume surgeons, which might be a

TABLE 1 Continued

Parameter	Patients (N = 934)
Nodal status: n (%)	
N ₀	703 (75.3)
N ₁ –N ₂	35 (3.7)
N _x	196 (21.0)
Organ-confined, n (%)	561 (60.1)
Positive surgical margins, n (%)	108 (11.6)
Pathologic Gleason score: n (%)	
2–6	403 (43.1)
7	467 (50.0)
8–10	60 (6.4)
not graded (pT ₀)	4 (0.4)
Specimen weight (g): median (IQR)	50 (40–60)

IQR, interquartile range. *Body mass index missing in 32 patients. †Not well documented in 15 patients.

TABLE 2 Frequency of medical and surgical complications

Complication	Frequency, n (%)
Medical complications (total n = 109)	
Cardiac	15 (14)
Pulmonary	5 (5)
Gastrointestinal (GI)	16 (15)
Neurological	3 (3)
Renal	3 (3)
Thromboembolic	12 (11)
Infections	55 (50)
Surgical complications (total n = 158)	
Urological	64 (41)
Lymphovascular	29 (18)
Gastrointestinal	5 (3)
Neurological	9 (6)
Musculoskeletal	12 (8)
Wound	34 (22)
Infections	5 (3)

limitation to the generalization of our results. The MRI was performed using an endorectal probe, which might have an impact on the soft tissue dimensions depending on the exact position of the probe. MRI was preoperatively performed for staging purposes, whereas MRI pelvimetric measurements were performed retrospectively. Not all patients treated with radical prostatectomy in the study period were staged with MRI. However, the distribution of pelvic dimensions is not expected to be different in patients who underwent MRI versus those who did not. We have chosen various pelvic dimensions primarily aimed at reproducibly evaluating pelvic size, the access angle to the operative field as well as prostate location, but other measurements may be considered. With regard to complications and their association with pelvic anatomy in prostate cancer surgery, this is currently the largest retrospective study performed. Despite the high number of cases in this retrospective study, differences may potentially be detected in a prospective designed trial. Our sample size limits the evaluation of the interaction of specimen weight and pelvimetric measures. A large prostate with a narrow pelvis would probably present more of a surgical challenge and a larger study would be needed to assess the impact of this on complications. Although a larger retrospective study cohort may identify a significant association between

TABLE 3 Multivariate Cox regression analysis for prediction of medical and surgical complications (882 cases in analysis)

Parameter	Odds ratio (95% CI)	P value
Predictors of medical complications		
Prostate-specific antigen*	1.39 (1.09–1.76)	0.008
RP approach (LP vs RRP)†	2.13 (1.40–3.23)	0.0004
Predictors of high-grade medical complications		
Vascular comorbidity	7.02 (1.68–29.4)	0.008
Predictors of surgical complications		
Prostate-specific antigen†	1.30 (1.06–1.59)	0.011
Modified Charlson score	1.21 (1.02–1.44)	0.031
Predictors of high-grade surgical complications		
Modified Charlson score	1.61 (1.26–2.06)	0.0001

*Odds ratio for doubling of prostate-specific antigen. †RP, radical prostatectomy, LP, laparoscopic prostatectomy; RRP, radical retropubic prostatectomy.

pelvimetric dimensions and the development of complications, the small magnitude of differences observed in this hypothesis-generating study brings into question whether a clinically meaningful impact of pelvic dimensions on the development of complications exists, even if a larger cohort is investigated. Our data suggest that anatomical variation of the pelvis and prostate location do not significantly impact on surgical technique with regard to the risk of developing complications after radical

prostatectomy in the hands of experienced surgeons.

ACKNOWLEDGEMENTS

This work was supported by The Sidney Kimmel Center for Prostate and Urologic Cancers.

CONFLICT OF INTEREST

None declared.

REFERENCES

- 1 Rabbani F, Yunis LH, Pinochet R *et al.* Comprehensive standardized report of complications of retropubic and laparoscopic radical prostatectomy. *Eur Urol* 2010; **57**: 371–86
- 2 Boyle KM, Petty D, Chalmers AG *et al.* MRI assessment of the bony pelvis may help predict resectability of rectal cancer. *Colorectal Dis* 2005; **7**: 232–40
- 3 Turner W. The index of the pelvic brim as a basis of classification. *J Anat Physiol* 1885; **20**: 125–43
- 4 Rabbani F, Herran Yunis L, Vora K *et al.* Impact of ethnicity on surgical margins at radical prostatectomy. *BJU Int* 2009; **104**: 404–8
- 5 von Bodman C, Matikainen MP, Yunis LH *et al.* Ethnic variation in pelvimetric measures and its impact on positive surgical margins at radical prostatectomy. *Urology* 2010; **16**: 1092–6
- 6 Dindo D, Demartines N, Clavien PA. Classification of surgical complications: a new proposal with evaluation in a cohort of 6336 patients and results of a survey. *Ann Surg* 2004; **240**: 205–13
- 7 Hong SK, Chang IH, Han BK *et al.* Impact of variations in bony pelvic dimensions on performing radical retropubic prostatectomy. *Urology* 2007; **69**: 907–11
- 8 Novara G, Ficarra V, D'Elia C, Secco S, Cavalleri S, Artibani W. Prospective evaluation with standardised criteria for postoperative complications after robotic-assisted laparoscopic radical prostatectomy. *Eur Urol* 2010; **57**: 363–70
- 9 Loppenberg B, Noldus J, Holz A, Palisaar RJ. Reporting complications after open radical retropubic prostatectomy using the Martin criteria. *J Urol* 2010; **184**: 944–8
- 10 Hong SK, Lee ST, Kim SS *et al.* Effect of bony pelvic dimensions measured by preoperative magnetic resonance imaging on performing robot-assisted laparoscopic prostatectomy. *BJU Int* 2009; **104**: 664–8
- 11 Mason BM, Hakimi AA, Faleck D, Chernyak V, Rozenblitt A, Ghavamian R. The role of preoperative endo-rectal coil magnetic resonance imaging in predicting surgical difficulty for robotic prostatectomy. *Urology* 2010; **76**: 1130–5
- 12 Matikainen MP, von Bodman CJ, Secin FP *et al.* The depth of the prostatic apex is an independent predictor of positive apical margins at radical prostatectomy. *BJU Int* 2010; **106**: 622–6

Correspondence: Farhang Rabbani, Department of Urology, Montefiore Medical Center, 111 East 210th Street, Bronx, NY 10467-2490, USA.
e-mail: frabbani@montefiore.org

Abbreviations: PSM, positive surgical margin; LRP, laparoscopic radical prostatectomy; BFW, bony femoral width; ISD, interspinous distance.