Image Guided Focal Therapy Of MRI-Visible Prostate Cancer: Defining a 3D Treatment Margin based on MRI-Histology Co-registration Analysis

Original Report

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Abstract

Purpose: To compare boundaries of prostate tumors on MRI and histologic assessment from radical prostatectomy (RP) using detailed software-assisted co-registration, in order to define an optimal treatment margin to achieve complete tumor destruction during image-guided focal ablation.

Methods: 33 patients who underwent 3T MRI before RP were included. A radiologist traced lesion borders on MRI and assigned a suspicion score (SS) from 2-5. 3D reconstructions were created from high-resolution digitalized slides from RP specimens and co-registered to MRI using advanced software. Tumors were compared between histology and MRI using the Hausdorff Distance (HD) and stratified by MRI-SS, Gleason Score (GS), and lesion diameter. Cylindrical volume estimates of treatment effects were used to define the optimal treatment margin.

Results: 46 histologically confirmed cancers underwent 3D software-based registration with MRI. MRI underestimated tumor sizes, with the maximal discrepancy between MRI and histologic boundaries for a given tumor averaging 1.99±3.1mm (18.5% of the MRI diameter). Boundary underestimation was larger for MRI-SS≥4 lesions (+3.49±2.1mm; p<0.001) and GS≥7 lesions (+2.48±2.8mm; p 0.035). On average, a simulated cylindrical treatment volume based on the MRI boundary missed 14.8% of the tumor volume compared with a simulated cylindrical volume based on the histologic boundary. A simulated treatment volume based on a 9mm treatment margin achieved complete histologic tumor destruction in 100% of patients.

Conclusion: MRI underestimates histologically-determined tumor boundaries, especially for high MRI-SS and high GS lesions. A 9mm treatment margin around an MRI-visible lesion consistently ensures treatment of the entire histologic tumor volume during focal ablative therapy.
INTRODUCTION

Focal therapy is gaining increasing interest as primary treatment for prostate cancer\(^1\). This trend is partly driven by growing awareness of the indolent nature and excellent survival of most new diagnoses, such that radical prostatectomy and radiation therapy, with their associated impact on quality-of-life, may not be warranted\(^2\). Although active surveillance provides a reasonable alternative for many patients with low risk tumors, this approach has limitations, including intensity of follow-up evaluation to which patients are subjected and associated anxiety of potentially missing the window of opportunity for cure\(^3\). While ablative therapy for prostate cancer historically entailed total, sub-total, or hemi-total ablation, more recent reports describe truly focal ablation procedures targeting the expected location of dominant tumors\(^4,5\). This approach is supported by emergence of newer ablation technologies, including laser-based thermotherapy\(^4,6\), focal cryoablation\(^7\) or photodynamic therapy\(^8\), that allow for more precise definition of the margins of tissue destruction. Thus, such procedures require a method to anticipate the margins of the tumor and thereby guide decisions regarding the boundary of the ablated region to avoid under-treatment.

The ability to precisely define the volume of focal lesions using MRI would be of immense value for guiding focal ablative therapy\(^9\). Past studies have compared tumor volumes between MRI and histopathological assessment\(^10,11,12,13\). Our group performed one such investigation using a previously validated automated three-dimensional (3D) coregistration system, employing affine transformation and compensation for changes in volume and shape\(^14\). In this earlier work, we observed consistent underestimation of tumor volumes by MRI\(^15\), indicating that actual tumors boundaries are expected to be located beyond the boundaries predicted by the visualized lesion on MRI. This difference in lesion boundary has a critical impact in planning and performing focal therapy procedures given that treatment of
only the MRI-visualized lesion will leave a portion of the tumor untreated in view of the larger histologic volumes. A method is therefore needed to define a target volume for focal therapy of an MRI-visualized lesion in order to reliably treat the entire tumor volume. Such a methodology will be important in achieving optimal oncologic control using emerging MRI-targeted focal therapeutic procedures.

Thus, our aim in this study was to compare the boundaries of prostate tumors between MRI and histopathological evaluation using co-registration software in order to define an optimal treatment margin to achieve complete tumor destruction at the time of image-guided focal ablation.

MATERIALS AND METHODS

Study Population

This retrospectively study was approved by our institutional review board. A waiver of written informed consent was granted. We initially identified 37 patients who underwent MRI at our center before prostatectomy and for whom a dominant tumor was identified on histopathologic assessment and visualized on the MRI. This cohort was evaluated in a prior study comparing tumor volumes on MRI and pathologic assessment from radical prostatectomy\textsuperscript{15}. Four of these 37 patients were then excluded because of a tumor volume bigger than 3cc on preoperative MRI given that patients with a lesion of this size would not be selected for focal therapy. Thus, the final cohort comprised 33 patients (mean age 60.7±5.4 years). These patients had a median pre-operative PSA at 4.8 ng/mL (range 0.32-19.5 ng/mL) including 27 patients with PSA<10ng/mL, 4 patients with PSA [10-15]ng/mL and 2 patients with PSA>15ng/mL.
MRI Data Acquisition

MRI was performed using a 3 Tesla whole-body system and a pelvic phased-array coil. Sequences included multiplanar T2-weighted imaging (T2WI); and axial diffusion-weighted imaging (DWI) of the prostate (b-values 50 and 1000 sec/mm$^2$), with apparent diffusion coefficient (ADC) reconstruction. Then, dynamic contrast enhanced (DCE) imaging of the prostate was performed using 0.1mmol/kg of gadolinium chelate and 5.5sec temporal resolution.

Histopathology Analysis

A standard Stanford protocol was used for pathological assessment, as previously described in detail$^{15,16}$. Photographs were taken of intact slices using a digital camera before further processing, and subsequent histological slides underwent high-resolution digitalization (400x magnification) using a Leica scan SN 400 (Leica-microsystems, Wetzlar, Germany). Digital images were combined to form virtual whole-mount images, using the photographs of the intact slices for guidance [Photoshop® software (Adobe, San Jose, CA)]. A single uropathologist marked the borders of tumors and recorded the Gleason score (GS) of each. Tumors were stratified into two groups: low-grade (GS 6) and high-grade (GS $\geq$7).

MRI Assessment and Co-registration with Histopathology

For each patient, a genito-urinary radiologist traced the boundary of the dominant lesion on each slice on which the lesion was visible. This was performed using solely T2WI in both the peripheral zone and the transition zone. The radiologist was aware of the general location of the dominant lesion from histopathologic assessment, but not of precise tumor boundaries. In addition, a score was assigned to each lesion on a 1-5 Likert scale to indicate
the likelihood of clinically significant cancer\textsuperscript{17}. These scores were then considered as low-suspicion (≤3) or high-suspicion (≥4).

Software was used to perform co-registration between MRI and digital 3D surgical specimens, constructed from the photographs of the gross slices. The initial reconstruction of the 3D specimen was performed using Image J\textsuperscript{®} software (V1.44e, NIH), and Photoshop\textsuperscript{®}. Subsequent co-registration with MRI was performed using previously described in-house software (FireVoxel, https://files.nyu.edu/hr18/public/).

**Simulation of Focal Therapy Treatment Volumes**

Two regions-of-interest (ROIs) were placed for each tumor: one corresponding with the lesion traced on T2WI, and the other corresponding with the lesion on the 3D histologic data set following co-registration with T2WI [registered histology (ReH)]. In order to compare tumor boundaries between T2WI and ReH, the software was first used to compute the Hausdorff distances (HD) between the two ROIs for each individual slice; the HD provides a single value representing the distance between the set of points represented by each ROI\textsuperscript{18,19}. Then, both a mean HD and maximum HD were calculated, corresponding to the mean and maximum HD across all of the slices comprising the tumor, respectively (Figure 1). Each HD was reported in both mm and the percentage of the lesion’s maximum diameter on T2WI. Finally, for each tumor, two cylinders centered around the lesion on T2WI were constructed to simulate potential focal therapy treatment zones: the MRI cylinder (MCyl), of which the diameter corresponded to the maximal lesion diameter on T2WI; and the Histologic cylinder (HCyl), of which the diameter corresponded to the summation of the maximal lesion diameter on T2WI and the maximum HD. Using this approach, the MCyl encompassed the entire lesion on T2WI, and the HCyl encompassed the entire co-registered histologic lesion. Figure 2 depicts the simulations of focal therapy using these different theoretical cylinders to
define the treatment zone. Subsequently, the software was used to calculate the volume of tumor that would be left untreated when targeting the MCyl, as well as the volume of benign tissue treated when targeting the HCyl.

Statistical Analysis

For each tumor, the mean HD and maximum HD were compared. HD was stratified based on imaging and histologic characteristics [GS, tumor size, and MRI Suspicion Score (SS)]. The various volume assessments were compared using paired t-tests and Wilcoxon tests for data with normal and non-normal distributions, respectively. The significant p-value threshold was defined at 0.05. SPSS version 14.0 was used for analysis.

RESULTS

Lesions Characteristics

Among the 33 included patients, 46 tumors were visualized: 37 (80.4%) in the peripheral zone, and 9 (19.6%) in the transition zone. On histologic assessment, 10 lesions were Gleason 6 (21.7%), 35 Gleason 7 (76.1%; 26 Gleason 3+4, 9 Gleason 4+3), and 1 Gleason 9 (2.2%). The MRI SS was categories as low in 14 (30.4%) and as high in 32 (69.6%). On T2WI, the mean tumor volume was 0.71±0.51cc, and the mean maximal diameter was 12.5±3.29mm. On registered histology, the mean tumor volume was 1.05±0.79cc, and the mean maximal diameter was 14.9±5.14mm. These characteristics are summarized in Table 1.

Assessment of Tumor boundaries

In general, MRI substantially underestimated tumor sizes. Accordingly, among all lesions, the mean HD was 0.50±0.86mm, and the maximum HD was 1.99±3.1mm. Maximum
HD was significantly larger for high-suspicion lesions (p=0.002), and for high-grade lesions (p=0.035) (Table 2). Figure 3 depicts the distribution of maximum HD values, stratified by tumor characteristics.

**Treatment margin**

Figures 4 and 5 compare tumor diameter on T2WI with the maximum HD corresponding to the hypothetical margin of the histologic lesion around the MRI lesion. This mean hypothetical histological tumor margin was 18.5% of the MRI tumor diameter (95% confidence interval, -32.1% to +69.2%). The depicted curves correspond to simulated treatment margins of 1mm, 5mm, and 9mm. 12 tumors (26.1%), 34 tumors (73.9%), and 46 tumors (100%), respectively, were located within the 1mm, 5mm, and 9mm treatment margin curves. Thus, all lesions were fully treated within the 9mm curve, regardless of the lesion’s MRI diameter, MRI SS, or GS. Table 3 represents the number and percentage of tumors totally treated stratified by the length of margin.

**Cylinder volumes and missed tumor**

Table 4 represents the volumetric simulations of focal treatment effect performed using cylinder volumes in 3D. For all lesions, the MCyl had a mean volume of 2.38cc (representing 5.3% of the prostate volume) and missed 0.16cc (14.8%) of the tumor volume on average. The HCyl had a mean volume of 4.32cc (representing 10% of the prostate volume) and was estimated to treat 100% of the tumor volume.

**DISCUSSION**

In previous work, we used 3D digital coregistration software to show that MRI substantially underestimates prostatic tumors volumes, and this underestimation is more
marked for high GS and high-suspicion lesions. These findings have key implications for image-guided focal therapy. Delivery of focally ablative treatment entails destruction of the tumor and a rim of benign tissue, it is therefore important to be able to estimate the margins of the tumor to guide the ablation procedure. Our results suggest that a much larger region of the prostate than that directly visualized on MRI warrants ablation to be confident of full tumor destruction. Specifically, our findings suggest that a treatment zone of approximately 20% larger than the apparent tumor on MRI will ensure treatment of the full tumor in over 95% of cases, and that a 9mm margin will ensure treatment of the tumor in all cases. The discrepancy in boundary between MRI and histology is most relevant at the lesion’s non-capsular margin given the tendency for tumors to originate close to the capsule and exhibit centripetal growth within the gland. Given that extraprostatic extension in patients undergoing radical prostatectomy generally resides within 3mm of the capsule, we suggest based on our data that image-guided focal ablation may optimally be performed using a combination of a 9mm non-capsular treatment margin and a 3mm capsular margin to balance complete tumor destruction and preservation of healthy tissue. Despite our choice of a cylindrical ablation volume, we believe our findings apply broadly to any form of focal therapy. As the maximal diameter of tumor utilized in our tumor size calculation resides in the center of the cylinder, our findings would theoretically be applicable even in the setting of a fusiform or spherical ablation zone.

Past studies of various forms of focal therapy in prostate cancer, have published results regarding cancer control based on biopsies after treatment. However only a few of these studies give details about the safety margin required during the procedure. Review of these studies suggests that approximately 20% of patients may have positive biopsies after focal treatments, although often with low-grade low-volume disease: for example, one study reported that 6 months after photodynamic therapy, around 20% of patients had a positive
biopsy\textsuperscript{8}; in another study using cryotherapy, biopsies were positive at one year in 19\% of patients, all with a GS of 3+3=6 in one or two cores\textsuperscript{23}. In contrast with our findings, an additional past study\textsuperscript{24} observed that on the non-capsular border, the median distance between the imaging and histopathological boundaries was only 1.4mm (range, 0-12), and that expanding the treatment zone by 5mm at the non-capsular margin allowed inclusion of 95\% of the tumor volume not initially covered within the MR contour. However, our results indicate the presence of more pronounced underestimation of MRI volumes, as we observed that a 5mm margin would cover only 74\% of the tumor, whereas a 9mm margin was needed to cover 100\% of the lesion. While the explanation for such differences in results is uncertain, our use of 3D coregistration technology to improve the reconstruction of the tumor’s histologic shape and its correlation with MRI suggests caution is warranted if applying the shorter treatment margins suggested by past literature.

We chose to evaluate individual lesions using an institutionally refined 1-5 Likert scale, because we have considerable experience with the scale, and have previously shown it to have similar diagnostic accuracy to the ESUR PI-RADS scoring scheme in the peripheral zone and somewhat better accuracy in the transition zone\textsuperscript{25}. Given the propensity of MRI to underestimate tumor size for intermediate and high risks tumors, caution should be exerted when selecting these men for focal ablation.

The nature of the tumor borders not visualized by MRI in planning focal therapy is not defined by our study. We have previously demonstrated that tumor detected on MRI is morphologically distinct from that not detected, within the context of individual tumors\textsuperscript{26}. While tumor not detected is typically lower grade and more sparse, it’s clinical significance with regard to risk of recurrence and progression is unknown. Future studies assessing the solid vs. sparse growth patterns of portions of tumors not visualized on MRI may help account for the underestimation of tumor volumes observed in this study\textsuperscript{27}. 

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Our study has a number of limitations. First, while our virtual whole mount methodology has not been previously tested for accuracy in tumor location, we feel that our coregistration methodology that accounts for gland deformation and shrinkage in the specimen remains a strength of our study. Second, while tumor boundaries were assessed solely on T2WI, a prior study showed greater underestimation of tumor volume using DWI and T2WI\(^\text{15}\), such that we believe T2WI may be the most commonly sequence used to guide focal ablation. Also, the radiologist was aware of the general location of tumors on histopathology, but not the borders, when tracing tumor boundaries on MRI. While this unblinded design precludes an assessment of reader accuracy in tumor localization, this approach facilitated ensuring that boundaries were compared between matching lesions on MRI and histology. In addition, the 3D morphology of the tumors was variable among patients and could not be adequately accounted for given our sample size. Finally, our findings are derived from computer-based simulations. Prospective clinical studies would be required to validate our estimations in patients actually undergoing focal ablative therapy.

**CONCLUSION**

We observed that MRI underestimated the boundaries of prostate tumors, particularly for high suspicion and high-grade lesions. Based on simulations using co-registration software, we found that a 9mm treatment margin around the MRI target consistently ensured treatment of the entire histologic tumor volume. This proposed 9mm treatment margin is optimally applied to the lesion’s non-capsular margin given the shorter degree of tumor extension that is expected along the lesion’s capsular margin. Such insights should be taken into consideration during planning of focal ablation targeting MRI lesions.
Acknowledgments

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Disclosure and financial interest

Julien Le Nobin MD, Andrew B Rosenkrantz, Arnauld Villers, Clément Orczyk, Fang-Ming Deng, Jonathan Melamed, Artem Mikheev and Henry Rusinek have nothing to disclose.

Samir S Taneja is consultant for Hitachi-Aloka, Biobot (unpaid), and Healthtronics, is speaker for Hitachi-Aloka, has Royalties from Elsevier, and is sponsored for clinical trials (Trod). No direct financial conflict of interest is identified.
References


TABLE LEGENDS

Table 1- Characteristics of patients and lesions

Table 2- Hausdorff Distance (HD) measurements and their percentage of the T2WI lesion diameter, stratified by the tumor characteristics [MRI suspicion score (SS), Gleason Score, and diameter]

Table 3- Number and associated percentage of tumors totally treated depending to the length of margin (1, 3, 5, 7 and 9 mm).

Table 4- Results of simulations of focal treatment using different theoretical cylinders to define the treatment zone.
FIGURE LEGENDS

**Figure 1**- Schematic demonstrating MRI lesion (blue) encompassed by histologic lesion (red). Green arrows represent Hausdorff Distances (HD) between lesions’ borders. The largest attainable HD on any MRI slice comprising the tumor is defined as the Hausdorff Max for the tumor.

**Figure 2**- Simulations of focal treatment using different theoretical cylinders to define the treatment zone. (A) Axial T2-weighted MR image of prostate showing right posterolateral lesion corresponding with dominant tumor on radical prostatectomy (arrow). (B) Depiction of boundaries of MRI lesion (blue overlay). (C) Superimposition of MRI lesion (blue overlay) and histologic lesion (red overlay). Hausdorff Max, representing the maximal attainable Hausdorff Distance between boundaries of the MRI and histologic lesions (as depicted in subsequent Figure), is indicated. (D) Superimposition of MRI lesion (inner overlay) encompassed by cylinder estimating the MRI-based treatment zone (outer overlay). (E) Superimposition of MRI lesion (inner overlay), histologic lesion (middle overlay), and cylinder estimating the treatment zone to achieve complete histologic destruction (outer overlay). (F) Superimposition of MRI-based (inner overlay) and histologic-based (outer overlay) treatment cylinders

**Figure 3**- Box and whiskers plots of the Maximum Hausdorff Distance between MRI and registered histology, stratified by tumor characteristics [Gleason score, Suspicion Score (SS), and lesion diameter].
**Figure 4**- Scatterplot of the Maximum Hausdorff Distance (HD), expressed as a percentage of MRI tumor diameter on T2-weighted imaging. Each point represents one patient. Horizontal lines represent mean±95% CI of maximum HD within cohort. Curves represent hypothetical treatment margins around a lesion with a given MRI diameter when applying treatment margins of 9 mm, 5 mm, and 1 mm; all data points fall within 9 mm curve.

**Figure 5**- Scatterplot of the Maximum Hausdorff Distance (HD), expressed as a percentage of MRI tumor diameter on T2-weighted imaging, for lesions with a high MRI suspicion score (4 or 5). Each point represents one patient. Horizontal lines represent mean±95% CI of maximum HD within this subset. Curve represent hypothetical treatment margins around a lesion with a given MRI diameter when applying treatment margins of 9 mm; all data points fall within this curve.
Tables

Table 1- Characteristics of patients and lesions

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean±SD</th>
<th>Median</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Patients (n=33)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age (years)</td>
<td>60.7±5.4</td>
<td>62</td>
<td>48</td>
<td>77</td>
</tr>
<tr>
<td>PSA (ng/mL)</td>
<td>6.4±3.4</td>
<td>4.8</td>
<td>0.3</td>
<td>19.5</td>
</tr>
<tr>
<td>Prostate volume on registered histology (cc)</td>
<td>46.6±16.3</td>
<td>42.0</td>
<td>18.0</td>
<td>99.8</td>
</tr>
<tr>
<td>Prostate volume on T2-weighed imaging (cc)</td>
<td>46.9±16.2</td>
<td>40.1</td>
<td>20.9</td>
<td>106.0</td>
</tr>
<tr>
<td><strong>Tumors (n=46)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gleason Score</td>
<td>-</td>
<td>7</td>
<td>6</td>
<td>9</td>
</tr>
<tr>
<td>MRI suspicion score</td>
<td>-</td>
<td>4</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>Tumor volume on T2-weighted imaging (cc)</td>
<td>0.7±0.5</td>
<td>0.4</td>
<td>0.1</td>
<td>3.2</td>
</tr>
<tr>
<td>Tumor volume on Registered Histology (cc)</td>
<td>1.1±0.8</td>
<td>0.7</td>
<td>0.1</td>
<td>4.5</td>
</tr>
<tr>
<td>Largest diameter on T2-weighted imaging (mm)</td>
<td>12.5±3.3</td>
<td>11.3</td>
<td>7.0</td>
<td>24.4</td>
</tr>
<tr>
<td>Largest diameter on Registered Histology (mm)</td>
<td>14.9±5.1</td>
<td>13.0</td>
<td>4.0</td>
<td>38.3</td>
</tr>
</tbody>
</table>
### Table 2- Hausdorff Distance (HD) measurements and their percentage of the T2WI lesion diameter, stratified by the tumor characteristics [MRI suspicion score (SS), Gleason Score, and diameter]

<table>
<thead>
<tr>
<th></th>
<th>Mean HD (mm)</th>
<th>% of MRI Diameter</th>
<th>Maximum HD (mm)</th>
<th>% of MRI Diameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>All tumors (n=46)</td>
<td>0.5±0.9</td>
<td>4.7±6.9 %</td>
<td>1.9±3.1</td>
<td>18.5±25.9 %</td>
</tr>
<tr>
<td>High SS (n=32)</td>
<td>0.9±0.6</td>
<td>7.5±4.5 %</td>
<td>3.5±2.1</td>
<td>29.3±17.3 %</td>
</tr>
<tr>
<td>Low SS (n=14)</td>
<td>-0.4±1.0</td>
<td>-1.6±9.4 %</td>
<td>-1.4±3.8</td>
<td>-6.1±36.4 %</td>
</tr>
<tr>
<td>Gleason ≥7 (n=36)</td>
<td>0.6±0.8</td>
<td>5.9±6.1 %</td>
<td>2.5±2.8</td>
<td>23.9±23.6 %</td>
</tr>
<tr>
<td>Gleason 6 (n=10)</td>
<td>0.1±1.0</td>
<td>0.2±8.3 %</td>
<td>0.2±3.8</td>
<td>-0.6±31.2 %</td>
</tr>
<tr>
<td>Diam &lt;10mm (n=15)</td>
<td>0.6±0.6</td>
<td>7.3±7.5 %</td>
<td>2.3±2.6</td>
<td>28.1±29.7 %</td>
</tr>
<tr>
<td>Diam ≥10mm (n=31)</td>
<td>0.4±0.9</td>
<td>3.4±6.7 %</td>
<td>1.8±3.5</td>
<td>13.9±24.5 %</td>
</tr>
</tbody>
</table>

Data represent mean ± standard deviation
Table 3- Number and associated percentage of tumors totally treated depending to the length of margin (1, 3, 5, 7 and 9 mm).

<table>
<thead>
<tr>
<th>Margin (mm)</th>
<th>1</th>
<th>3</th>
<th>5</th>
<th>7</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number (%) of tumors totally treated</td>
<td>12 (26.1)</td>
<td>25 (54.3)</td>
<td>34 (73.9)</td>
<td>43 (93.5)</td>
<td>46 (100)</td>
</tr>
</tbody>
</table>
Table 4- Results of simulations of focal treatment using different theoretical cylinders to define the treatment zone.

<table>
<thead>
<tr>
<th>Cylinder Diameter (mm)</th>
<th>Cylinder Volume (cc)</th>
<th>Missed Volume (cc)</th>
<th>% Missed Volume</th>
<th>Treated Benign Volume (cc)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MCyl 12.2</td>
<td>2.38 (5.3% gland volume)</td>
<td>0.16</td>
<td>14.8%</td>
<td>1.42</td>
</tr>
<tr>
<td>HCyl 16.2</td>
<td>4.32 (10% gland volume)</td>
<td>0</td>
<td>0%</td>
<td>3.14</td>
</tr>
</tbody>
</table>

MCyl and HCyl correspond to cylinders based on the largest diameter of the T2WI lesion and the largest diameter of the Registered Histologic lesion, respectively. Missed Volume represents the volume of tumor that would be left untreated when targeting the MCyl. Treated benign volume represents the volume of benign tissue treated when targeting the HCyl. Values represent mean value within patient cohort.
Key of Definitions for Abbreviations

- GS = Gleason Score
- HD = Hausdorff Distance
- HCYl = Histologic cylinder
- MRI = Magnetic Resonance Imaging
- MCyl = MRI cylinder
- ROI = Regions-Of-Interest
- RP = Radical Prostatectomy
- SS = Suspicion score
- T2W = T2-weighted