CLINICAL INVESTIGATION

TIME TO METABOLIC ATROPHY AFTER PERMANENT PROSTATE SEED IMPLANTATION BASED ON MAGNETIC RESONANCE SPECTROSCOPIC IMAGING

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Purpose: To characterize the time to metabolic atrophy (TMA) after permanent prostate implantation (PPI) using combined MRI and magnetic resonance spectroscopic imaging (MRSI) compared with the time to prostate-specific antigen (PSA) nadir.

Methods and Materials: This study was based on a posttreatment analysis comparing the MRI/MRSI findings with the PSA levels of 65 patients treated with PPI alone or combined with external beam radiotherapy and/or HT. The fraction of interpretable voxels demonstrating metabolic atrophy was used to compare the TMA with the time to PSA nadir.

Results: The fraction of patients with metabolic atrophy in >95% of usable voxels after PPI increased from 46% to 100% at 6 and 48 months, respectively. The mean time for PSA nadir vs. TMA was 42.5 vs. 28.9 months (PPI), 32.8 vs. 25.6 months (external beam radiotherapy + PPI), and 25.3 vs. 28.0 months (external beam radiotherapy + hormonal therapy + PPI).

Conclusion: Magnetic resonance spectroscopic imaging may provide an early tool for evaluating the treatment response for patients treated with PPI. If supported by longer follow-up, TMA may be a useful adjunct to PSA measurement for assessing local control after PPI and could be useful in evaluating the complex relationships between the quality of the implant and the time to indication of successful therapy. © 2004 Elsevier Inc.

Magnetic resonance spectroscopy imaging, MRI, Permanent prostate implant, Brachytherapy, PSA nadir.

INTRODUCTION

The serum prostate-specific antigen (PSA) test is the most commonly used method of confirming resolution of prostate cancer after definitive radiotherapy (RT). PSA testing is used universally and is considered to be a fairly reliable and inexpensive determination of treatment outcome. However, benign PSA bounces occur in up to 30% of patients aged <65 years, with those with large gland sizes and relatively “hot” implants having a greater risk of PSA bounce (1). The use of PSA testing to monitor therapeutic efficacy is not ideal, because PSA is not specific for local recurrences of prostate cancer. Additionally, it can sometimes take >4 years for the PSA level to reach a nadir after brachytherapy (2). The PSA data are more complicated for patients undergoing hormonal deprivation therapy (HT) because of the direct effect on the production of PSA. MRI alone often cannot distinguish healthy from malignant tissue after therapy because of the induced changes in the tissue structure (3).

Magnetic resonance spectroscopic imaging (MRSI) is increasingly being used in patients with newly diagnosed prostate cancer for tumor localization and staging (3). MRSI has been used experimentally in >3900 patients as an adjunct to MRI at the University of California, San Francisco, Medical Center (UCSF) (4–9) for staging and tumor localization (7–10). The patient data are currently presented at a weekly tumor board and used in conjunction with other clinical parameters to select the most appropriate individualized therapy. MRSI allows the noninvasive identification of areas of prostate cancer based on significant changes in choline, polyamines, and citrate peaks relative to regions of healthy peripheral zone tissue (6, 7, 9). Before therapy, prostate cancer can be identified on the basis of a low signal intensity on T2-weighted MRI and significantly elevated
choline/creatinine ratios and reduced citrate and polyamine levels on MRSI. It is the concordance of the metabolic findings provided by MRSI and the morphologic findings provided by MRI that results in the most confident identification of prostate cancer (11). Regions of cancer defined by combined MRI/MRSI can also be registered with transrectal ultrasound images and/or postimplant CT images for more accurate tumor localization, treatment planning, and visualization of isodose distributions (12).

Recently, we began using MRI/MRSI to monitor patients over time after RT. After therapy, the ability to identify prostate cancer on MRI is reduced owing to a diffuse reduction in the T2-weighted signal. Levels of citrate and polyamines are also dramatically reduced on MRSI (3). However, residual prostate cancer can still be identified by a relative increase in the choline/creatinine ratio (3). MRSI can also provide a quantitative measure of successful therapy by the indication of a lack of metabolic activity or “metabolic atrophy” (MA). MA, the primary indicator in this study, has been previously defined as “spectra containing no significant metabolite peaks, specifically spectra having peak area/noise ratios of <5 for choline, polyamines, creatine and citrate” (13).

The current study was based on the hypothesis that MA is indicative of successful treatment because the growth of normal or abnormal cells cannot occur without metabolism, and a loss of metabolism may provide an earlier indicator of therapeutic success than the PSA nadir. Our purpose was, therefore, to characterize the time course to achieve MA after permanent prostate seed implantation (PPI) using combined MRI and MRSI as compared to the time to PSA nadir.

METHODS AND MATERIALS

Patient selection

More than 700 PPI patients were treated at UCSF between June 1996 and July 2003. This group of patients was cross referenced with the MRI/MRSI database to identify patients with pretreatment MRI/MRSI and/or posttreatment MRI/MRSI findings as an initial starting point for patient selection. Patients were asked to participate in this study and prioritized on the basis of those with the lowest minimal postimplant isodose coverage. If interested, they were screened for contraindications and provided an informed consent to participate in the UCSF MRI/MRSI institutional review board–approved study (14). Successful recruitment to this study was complicated by several factors, including the availability of research MRSI time, patients living out of the area, patients having obtained metal prostheses, patient discomfort, and patients lost to follow-up.

All patients included in this study had had PSA testing before treatment and at various times after treatment. Ultimately, 70 patients were registered for participation. For the purposes of this protocol, it was decided that each patient would be followed until achieving the primary end point, defined as MA in >95% of the imaged voxels in the setting of a nonrising PSA level.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>PSA level (ng/mL)</th>
<th>GS (range)</th>
<th>Stage (n)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group 1 (n = 39)</td>
<td>Mean 7.4</td>
<td>6</td>
<td>T1, 17</td>
</tr>
<tr>
<td></td>
<td>Median 6.5</td>
<td></td>
<td>T2, 22</td>
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<tr>
<td></td>
<td>Range 19.5</td>
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<tr>
<td>Group 2 (n = 13)</td>
<td>Mean 9.1</td>
<td>5–6.2</td>
<td>T1, 6</td>
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<tr>
<td></td>
<td>Median 7.7</td>
<td></td>
<td>T2, 6</td>
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<tr>
<td></td>
<td>Range 14.3</td>
<td></td>
<td>T3, 1</td>
</tr>
<tr>
<td>Group 3 (n = 13)</td>
<td>Mean 9.4</td>
<td>6–6.2</td>
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</tr>
<tr>
<td></td>
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<td>T2, 11</td>
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<tr>
<td></td>
<td>Range 17.8</td>
<td></td>
<td>T3, 1</td>
</tr>
</tbody>
</table>

Abbreviations: GS = Gleason score; PSA = prostate-specific antigen.

Patient exclusion

Five initially registered patients were later excluded. One patient refused to return for a follow-up study. One patient became nauseated during the study, was unable to continue, and refused to return for a follow-up study. One patient achieved MA after 6 months but had documented evidence of distant disease and a PSA rise of 50 ng/mL. One patient had been treated with high-dose-rate brachytherapy outside UCSF and brachytherapy was used as salvage therapy for local recurrence. Finally, 1 patient had a posttreatment-implanted titanium stent, violating the MRI/MRSI participation criteria. This patient was free of disease 6 years after treatment, with an undetectable PSA level.

After these exclusions, 65 patients remained in the study: 39 patients received PPI alone, 13 patients received external beam RT (EBRT) + PPI, and 13 patients received EBRT + HT + PPI. Table 1 summarizes the pretreatment PSA level, Gleason score, and stage for these patients.

PPI planning technique

The brachytherapy planning process began at weekly multidisciplinary imaging/treatment planning conferences that included representatives from the departments of radiation oncology (radiation oncologist and physicist), radiology (radiologist, nurse, and physicist), and urology (urologist). The treatment options, including PPI alone, EBRT + PPI, and EBRT + HT + PPI, were discussed. Both 103Pd and 125I isotopes were used. The dose prescribed for patients treated with EBRT + PPI was 100 Gy for 103Pd and 108 Gy for 125I, and without EBRT was 120 Gy for 103Pd and 144 Gy for 125I. No adjustment in dose was made when HT was prescribed. Seed activities and procedures conformed to Task Group-43 National Institute of Standards and Technology 99 standards (15). Our goal was to deliver >90% of the prescribed dose to the entire prostate gland while delivering 100% of the prescribed dose to the MRSI-defined cancerous sites.

Treatment methods

The PPI was performed using peripheral loading, with special consideration given to avoiding needle placement...
near or through any part of the urethra. The most posterior row of needles was placed approximately 0.5 cm away from the anterior rectal wall to minimize rectal morbidity, and an effort was made to minimize the quantity of needles used. Pretreatment MRSI was done on 42% of the patients in the study. In these patients, additional seeds were placed into the MRSI-defined localized regions of cancer. In the other 58% of patients, additional seeds were placed in the biopsy-defined tumor locations on the basis of the pathologic findings. Postimplant dosimetry was done 2 and 4 weeks after 103Pd and 125I, respectively.

Hormone therapy was incorporated into the treatment regimen for a subgroup of patients. The indications for neoadjuvant and concurrent HT were to reduce the prostate size, minimizing pubic arch interference; a >15% risk of lymph node involvement (these patients also underwent pelvic RT to address microscopic pelvic nodes) (16); and HT prescribed by referring physician prior to PPI for unknown reasons.

None of these patients received long-term, adjuvant, HT. When HT was prescribed, it began before RT and was discontinued at the end of RT. For all patients, the MRI/MRSI study was performed >6 months after HT (17). All men had recovery of testosterone (tested before MRSI) and/or resolution of all HT-induced symptoms (e.g., “hot flashes”) before participating in the study.

All patients underwent at least one posttreatment MRSI study. The time course was measured from the end of treatment, regardless of the treatment type. All patients were evaluated at a multidisciplinary MRI/MRSI conference, at which the MRI and MRSI results were individually assessed for the presence of residual/recurrent cancer. If either the MRI or MRSI data demonstrated evidence of residual disease or proved to have an inconclusive or borderline reading, the patient was followed further.

MRI technique

The MRI technique has been described in detail previously (6, 8, 19). MRI was performed with a 1.5T whole body MR unit (Signa, GE Medical Systems, Milwaukee, WI). A body coil was used for excitation in the supine patient. A commercially available endorectal coil (Medrad, Pittsburgh, PA) was used in conjunction with a pelvic phased-array coil (GE Medical Systems, Milwaukee, WI) for signal reception. After acquisition of a sagittal T2- weighted images were obtained from below the aortic bifurcation. All images were then processed to compensate for the reception profiles of the pelvic phased-array and endorectal coils (8).

Three-dimensional MRSI technique

The three-dimensional (3D) MRSI technique has also been previously described in detail (6, 8, 19). Using transverse T2-weighted images, an optimal spectroscopic image volume (maximal prostate coverage with inclusion of minimal periprostatic fat and rectal air) was selected using the double-spin-echo point-resolved spatially localized spectroscopy technique (6). Water and lipid peaks were suppressed using band-selective inversion with gradient dephasing or BASING (19). The flip angle of the BASING pulses was reduced to leave residual water in proton spectra. The presence of a residual water resonance in the absence of detectable prostatic metabolites after therapy was used to assess the technical success of the MRSI acquisition. Very selective outer voxel saturation pulses were also used to eliminate spectral contamination from susceptibility shifted water and periprostatic fat (20). MRSI data sets were acquired as 16 × 8 × 8 phase-encoded spectral arrays (1024 voxels) with a nominal spectral resolution of ~0.3 cm⁻³, TR/TE of 1000 ms/130 ms, and a 17-min acquisition time. The total examination time was 1 h, including coil placement, patient positioning, and data acquisition.

Gland coverage for MRSI

The 65 patients in the study were evaluated for spectroscopic coverage of the prostate. The prostate size ranged from 14.5 to 58.9 cm³ (mean 25.5, median 27.3). The percentage of the gland covered by MRSI ranged from 65% to 100% (mean 95%, median 95.2%). Thus, on average, approximately 5% of the gland was inadequately covered by the MRSI study, with this region generally restricted to the very anterior aspect of the central gland and the most superior aspect of the prostatic base.

3D MRSI data processing and analysis

The 3D-MRSI data were processed off-line on an Ultra-Sparc workstation (Sun Microsystems, Mountain View, CA) using software previously developed at the UCSF. All spectral data were apodized with a 2-Hz gaussian function and Fourier transformed in the time domain and three spatial domains. Corrections to phase, baseline, and frequency were carried out (21). The metabolites of interest (i.e., creatine, choline, polyamines, and citrate) were then integrated to determine their relative peak areas. Peak area/spectral noise ratios were calculated for all prostate metabolites. Spectroscopic voxels lacking any metabolite peak area/noise ratio greater than five were considered metabolically atrophic. Spectroscopic voxels containing detectable metabolite peaks were labeled as either borderline (metabolite peak areas barely five times the spectral noise) or clear cut (metabolite peak areas much larger than the spectral noise). Healthy metabolism was identified on the basis of the presence of high levels of citrate and lower, approximately equal, levels of choline, creatine, and polyamines,
similar to the levels before therapy (6). Residual prostate cancer was discriminated from residual healthy tissue on the basis of a choline/creatine peak area ratio of ≥1.5 (22). The percentage of the gland with atrophic and residual metabolism (borderline and clear cut) was calculated on the basis of the total number of voxels interrogated. The presence or absence of recurrent or residual cancer was determined using the concordant MRI and MRSI findings provided in the clinical radiology report. Figure 1 shows the peak area spectra studied on axial T2-weighted MRI scans of the prostate with spectroscopy voxels. In Fig. 1, the pre- and posttreatment spectra show high choline peaks, high citrate peaks, and MA (lack of identifiable peaks), indicating cancerous and healthy tissue and successful therapy, respectively.

Additional analyses

For all patients, the mean minimal dose coverage from the PPI and the range of minimal doses from the PPI were evaluated. The combined patient data (results of all follow-up studies) were tabulated and graphed by treatment group. Least squares fits of saturating exponential functions were performed to the combined time course data for ease of interpretation. Additionally, the cumulative data of each individual patient were assessed, and the time point (relative to the date of PPI) for each patient indicating >95% MA was noted, even if that time point was late in the follow-up and it was their only study. This necessity (inclusion of patients with only one, late follow-up study) biased (overestimated) the individual time to >95% MA results to longer periods. It could well be expected that many of these men had achieved >95% MA at some prior point. The individual times to >95% MA data were segregated by treatment group, and the mean time to >95% MA, median time to >95% MA, and range of time to >95% MA were documented for each group.

Time course to PSA nadir

All available PSA results for the 65 patients studied were tabulated and graphed. Additionally, the time to PSA nadir after therapy was documented. PSA nadir was determined when the PSA had stabilized at its lowest level (typically <0.1 ng/mL). The available results were graphically represented for visualization of the so-called PSA blip and for comparison with the time to >95% MA. In most cases, the PSA level had declined immediately after PPI and then a series of blips occurred until nadir.

RESULTS

Overall MRI/MRSI results

The fraction of all patient MRSI studies (regardless of treatment option) with >95% of their spectroscopic voxels indicating MA increased from ~46% within the first 6 months after PPI to ~77% at 6–24 months, ~87% at 24–48 months, and 100% at >48 months (Fig. 2). Similarly, the fraction of MRI examination demonstrating clear-cut levels of prostate metabolites decreased from ~38% at <6 months to ~17% at 6–24 months, ~13% at 24–48 months, and 0% at >48 months (Fig. 3). Only clear-cut reports of residual cancer were

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**Fig. 1.** Axial T2-weighted MRI scans of prostate with spectroscopy voxels overlaid and corresponding spectra on right. (Upper panel) Before treatment. (Lower panel) After treatment. Endorectal probe shown in lower portion of each image; only spectra covering peripheral zone shown for simplicity. (Upper panel) Peaks for major metabolites (citrate, choline, and creatine) easily seen. Healthy metabolism (left) characterized by high citrate relative to choline + creatine; cancerous metabolism (right) characterized by high choline + creatine relative to citrate. (Lower panel) After successful treatment, complete lack of identifiable peaks above baseline noise. Integrity of study confirmed by observation of residual water peak at correct position (inset) of the spectral range shown for other metabolites.

**Fig. 2.** Fraction of all patient scans in each follow-up interval having >90% (dotted bars) and 95% (lined bars) of prostate spectroscopic voxels indicating metabolic atrophy. Trend lines added for guidance.
found at 24–48 months. This sharp decrease with time in the percentage of MRSI examinations containing clear-cut, non-atrophic spectra signified that many of the remaining spectroscopic voxels associated with the data in Fig. 2 contained only borderline indications of metabolic activity. The overall effectiveness of the treatments was also indicated by the corresponding decrease in the number of clinical MRI/MRSI reports indicating cancer during this same period (Fig. 3).

**Overall MRSI results by treatment group**

Figures 4 (PPI alone), 5 (EBRT + HT + PPI), and 6 (EBRT + PPI) illustrate the time trends in an increasing percentage of prostate spectroscopic voxels indicating MA (successive scans of the same patient are connected by dotted lines). The thick solid lines are the least squares fits of a saturating exponential function to each data group, drawn for guidance in summarizing the behavior of the data. The last two groups had only 13 patients each.

**Results of brachytherapy alone**

The 39 patients treated with PPI alone had a mean and median minimal dose of 84.5% and 88.1%, respectively, and the minimal doses from the PPI portion of the implant ranged from 46.9% to 99.3%. For these 39 patients, the mean and median individual patient time to >95% MA was 28.9 and 24 months, respectively (Table 2). Patients underwent MRI/MRSI examination as early as 2 months and as late as 60 months after PPI, and several patients underwent only one therapeutic follow-up examination (Fig. 4). As stated, the first point for each patient with >95% of the spectroscopic voxels indicating MA was used in computing the above mean and medium values. This implies that (as stated previously) in several cases, although the exact point to >95% MA for a particular patient was unknown, those times were likely shorter than the values used in the averaging.

**Results of EBRT + PPI**

Thirteen patients treated with EBRT before PPI received a mean and median minimal dose of 85.7% and 92.2%, respectively, and minimal doses from the PPI portion of the implant ranging from 47.8% to 100%. For these 13 patients, the mean and median time to >95% MA was 25.6 and 26 months, respectively (Table 3), and the time of the follow-up MRI/MRSI examination for these patients ranged from 3 to 51 months after therapy (Fig. 5).
Results of EBRT/H11001 HT/H11001 PPI

Thirteen men treated with EBRT/H11001 HT/H11001 PPI had a mean and medium minimal dose of 82.8% and 88.1%, respectively, and minimal doses from the PPI portion of the implant ranging from 61.1% to 99.7%. For these 13 patients, the mean and median time to >95% MA was 28.0 and 25.0 months, respectively (Table 4), and the follow-up times for these patients ranged from 13 to 62 months after therapy (Fig. 6). In this small group of patients, 3 of the 13 patients underwent only a single study 44–62 months after therapy. Without these 3 patients, the time to >95% MA would be 20.6 months (range, 13–28 months).

Residual healthy and malignant metabolism

In 6% of the patients studied, spectroscopic voxels demonstrating healthy metabolism were observed in the peripheral zone in regions near the urethra and ejaculatory ducts. In 11% of the patients, spectroscopic voxels demonstrating healthy voxels were observed in the central gland. The healthy voxels were found in both PPI alone and PPI + EBRT patients, but not in patients receiving HT. In 3% of the patients, healthy voxels were observed at the time the patient had already attained >95% MA.

Cancerous metabolism was found in 42% of the patients studied within 24 months of treatment. This group of patients had <95% MA and persistent “PSA blips.” Serial yearly follow-up MRSI demonstrated a decreasing number of voxels with malignant metabolism that eased concern about local recurrence.

Results of PSA nadir by treatment group

In addition to MRI/MRSI studies, each patient had a pre-treatment and at least one posttreatment PSA (Fig. 7). Table 5 summarizes the mean time to >95% MA compared with the mean time to PSA nadir for each treatment group. Patients undergoing PPI alone had a mean time to PSA nadir of 42.5 months (~18 months longer than the average time for these patients to attain >95% MA). The EBRT + PPI patients had a PSA nadir at a mean of 32.8 months (~7 months longer than the average time for these patients to attain >95% MA). Patients receiving EBRT + HT + PPI had a PSA nadir at 25.3 months (approximately the same time scale as for the average time to >95% MA). Thirty-one percent of the patients in this study had a series of PSA blips until an eventual decline or nadir occurred; however, viable metabolism continued to decrease during the PSA blips.

DISCUSSION

The treatment of prostate cancer continues to be somewhat controversial in part because of the need for long follow-up to determine outcomes, including “cure.” If a relatively noninvasive imaging approach could be used to determine the success of therapy, it could be incorporated as a surrogate end point, thus potentially shortening the time...
required to determine successful treatment outcomes. The results of this study suggest that MA after PPI may complement PSA nadir as a measure of therapeutic effectiveness. For patients receiving PPI alone or PPI + EBRT, the mean time to >95% MA was shorter than the mean time to a PSA nadir. For patients receiving HT in addition to PPI and EBRT, the times were comparable. In this group of patients, interpretation of the earlier PSA nadir was complicated because HT can lower PSA into the undetectable range without sterilizing the disease. Because of the spread of time points for the individual patient MRSI studies (and because some patients had only one study late in follow-up; Figs. 4–6), it is likely that the actual mean time to >95% MA was shorter than those reported. However, only additional follow-up can prove that the atrophic voxels will not demonstrate recovery of metabolism at any future point after atrophy. If these findings hold up with longer follow-up, MRSI could be used as a surrogate end point for local control of prostate cancer.

All 65 patients experienced an initial decline in PSA during the first 6 months after PPI. However, 31% of the patients in this study had a series of PSA blips until an eventual decline or nadir occurred (Fig. 7). Although the typical increases in PSA have been reported in the literature to range on average from 0.2 to 3.4 ng/mL, much higher “blips” have occasionally been observed that have lasted for ≥18 months (22). However, the presence of a PSA “blip” does not seem to be generally associated with a greater risk of clinical failure. It is likely that as the cells die, PSA is released into the blood, causing a series of temporary rises, spikes, or “blips,” delaying the PSA nadir. Other possible causes of the PSA “blips” include delayed death of epithelial cells or radiation-induced prostatitis (23). However, these “blips” cause unease in treated patients and physicians alike and can occur within a broad range of time points and have varying durations. In this study, viable metabolism continued to decrease during the PSA blips, indicating that the PSA blips were not associated with an increase in residual healthy or cancerous prostate epithelial cells. Therefore, MRI/MRSI may also help in easing the minds of patients experiencing these transient PSA rises.

In this study, early metabolic responses were observed in all three cohorts of patients receiving PPI, with >90% of the prostate gland of most patients demonstrating predominately MA at early points. Furthermore, the amount of MA continued to increase with time, with all patients attaining >95% MA by 48 months after therapy. However, regions of residual/recurrent healthy metabolism (high citrate, low choline and creatine) were observed in both the peripheral zone (6% of studies) and the transition zone (11% of studies) of patients after PPI alone and PPI + EBRT. In the peripheral zone, the regions of healthy metabolism were typically observed around the midline structures. The location of residual healthy metabolism in these regions may have been, in part, a result of the use of a peripheral loading technique with the goal of sparing the critical structures around the urethra and ejaculatory ducts. However, we observed a relatively small number of voxels demonstrating metabolism indicative of cancer at any point after PPI (as demonstrated in the present study and also on the basis of metabolic criteria defined in a recent study of patients with biopsy-proven cancer after EBRT) (24). All of these findings may have been a result of the impact of higher doses of 

Table 5. Mean time to PSA nadir and >95% MA

<table>
<thead>
<tr>
<th>Group</th>
<th>Mean time to PSA nadir (mo)</th>
<th>Mean time to T &gt; 95% MA (mo)</th>
<th>PSA nadir – T &gt; 95% MA (mo)</th>
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</thead>
<tbody>
<tr>
<td>PPI alone</td>
<td>42.5</td>
<td>28.9</td>
<td>13.6</td>
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<tr>
<td>EBRT + PPI</td>
<td>32.8</td>
<td>25.6</td>
<td>7.2</td>
</tr>
<tr>
<td>EBRT + HT + PPI</td>
<td>25.3</td>
<td>28.0</td>
<td>-2.6 (PSA nadir before MRSI)</td>
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<tr>
<td>EBRT + HT + PPI (excluding patients with one long time point)</td>
<td>25.3</td>
<td>20.6</td>
<td>4.7</td>
</tr>
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</table>

Abbreviations: PSA = prostate-specific antigen; T > 95% MA = time to >95% metabolic atrophy.
radiation, patient selection, duration of follow-up, or other factors not yet identified.

In this study, 42% of the patients underwent a pretreatment MRI/MRSI examination, and in 69% of these patients, serial follow-up MRI/MRSI examinations were also acquired. The pretreatment number of cancerous voxels could be used as a baseline to determine the time to disease regression in many patients and, with further investigation, might provide a clue to determine whether the quantity of pretreatment cancerous voxels effects the total time to MA for the different treatment techniques.

This research did not address the cost associated with routine use of MRSI for determining local control after PPI. The time to MA associated with the successful treatment of brachytherapy patients (PPI alone, PPI + EBRT, and PPI + EBRT + HT) was the focus of this research. We will continue to follow our current patients and add new patients on a routine basis to confirm the time to >95% MA for each group. The cost and benefits associated with this noninvasive technique remain to be shown with longer follow-up and more patients.

CONCLUSION

This is the first study to describe the time to MA after PPI. “Benign PSA blips” were not associated with an increase in metabolic activity, which might suggest that these “blips” are secondary to the death of epithelial cells leaking into the bloodstream. The detection of residual cancer at an earlier time after treatment could allow earlier intervention with additional therapy and provide a more quantitative assessment of therapeutic efficacy. The results of this study suggest that MRSI could provide an earlier indicator for resolution of local disease than PSA nadir, thus providing greater security to both patients and their physicians. If supported by longer follow-up, the time to MA may be a useful adjunct to PSA determination for assessing local control after PPI and could be useful in evaluating the complex relationships between the quality of the implant and the time to the indication of successful therapy. Longer follow-up is required to confirm these initial observations.

REFERENCES

