
Quantitative MRI monitoring on a 0.35 T MR-Linac during and up to 1-year after prostate SBRT treatment

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Résumé

Introduction: MR-linac imaging during treatment simplifies logistics, allowing quantitative MRI (qMRI) to be acquired seamlessly for patients during prostate SBRT sessions, typically performed at the same institution as follow-ups. Prostate SBRT is a prime indication for MR-linac, and an appropriate organ to begin with qMRI given its limited movement. This study aims to (1) showcase the first 0.35T qMRI study on patients in the pelvis and (2) explore post-treatment dynamics on the prostate and surrounding organs.

Material and Methods: Acquisitions were performed on the MRIdian 0.35T system (Viewray, Denver, USA) with two 6-channels TORISO coils. The DESPOT-DIXON qMRI protocol (1) was conducted providing T1, T2, and T2* biomarkers maps through four 3D steady-state acquisitions: two 3-echoes SPGR and two bSSFP sequences.

25 patients were recruited in this study. They received prostate SBRT either 4×9.5 Gy (n=11) or 5×7.25 Gy (n=14). Five time points were acquired: treatment preparation, treatment end (t=0), 3, 6, and 12 months post-treatment follow-up. MRI mappings and subsequent image analyses were performed on in-house code using MATLAB R2021a.

Metric normalization referenced treatment preparation. Follow-up time points were relative to treatment end. Metrics analysed for the pelvic region (prostate, bladder, rectum, bone marrows and muscles) included mean, standard deviation, skewness, and 1st/3rd quartiles. Wilcoxon tests, Bonferroni-corrected, ($p < 0.025$, 0.005, 0.0005) were used in order to compare the baseline with follow-up points. The two subgroups of treatment plan were compared using Mann-Whitney test with the same significance thresholds.

Results: Out of the 25, 17 patients completed all MRI sessions, data imputations were performed for the remaining 8 with one time point missing or spoiled. The pubic arch demonstrated significant conversion from red to yellow marrow after 3 months ($p < 0.00005$), with similar but less pronounced changes observed in femoral head marrow ($p < 0.0005$). Prostatic tissue exhibited significant decreases in first quartile T2* values after 3 months ($p < 0.00005$), alongside concurrent reductions in T1 and T2 1st quartiles ($p < 0.0005$). Significant dose-dependent differences ($p < 0.025$) emerged between prescription groups after 3

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months, specifically in T1 standard deviation and T2* first quartile parameters, suggesting differential tissue response mechanisms based on treatment intensity.

Conclusions: This study is the first to apply qMRI on a 0.35 T system with more than one-year follow-up in prostate cancer, demonstrating bone marrow and prostate response to treatment. Relaxometry MR biomarker values could be used for future MR optimization and development at this field strength. The proposed quantitative method find itself robust considering the several confounding factors of a 1-year long patient follow-up. The dose difference sensibility of some metric seems promising to be added in future clinical trial quantitative data.

References

1. Marage et al., Multi-parametric MRI on a 0.35 T MR-LINAC: application to prostate radiotherapy treatment follow-up, Abstract #2215, ISMRM 31th annual meeting, London, 2022

Mots-Clés: MR, linac, MRgRT, Quantitative MRI, Prostate