Grand Valley State University
Medical Dosimetry

Karen Weeks, B.S., RT (R)(T)
Grand Valley State University
weekska@mail.gvsu.edu

Evaluate MRCAT as a Surrogate for Traditional CT Simulation in Proton Prostate Radiotherapy Planning

Introduction

Proton therapy offers highly conformal dose delivery with excellent sparing of healthy tissues in prostate cancer treatment. Traditional CT simulation is vital for accurate dose calculations and proton range verification. While MRI provides superior soft tissue contrast for target delineation, combining it with CT introduces registration uncertainties. MRI-only workflows, using synthetic CT generation, offer a potential solution to improve accuracy and streamline the planning process

This study evaluates the Philips MRCAT (MR for Calculating Attenuation) as a surrogate for conventional CT in double-scatter proton therapy planning for prostate cancer. MRCAT uses atlas-based and segmentation algorithms to produce electron density-equivalent synthetic CT images from MRI data. Although validated for photon planning, MRCAT's use in proton therapy remains underexplored. This research assesses the clinical feasibility of MRI-only workflows in proton prostate radiotherapy by comparing Hounsfield Unit (HU) accuracy, dose distributions, and dosimetric endpoints between MRCAT and traditional CT-based plans. The findings aim to inform future adoption of standardized synthetic CT protocols and support MR-only planning in routine clinical practice.

Methods

A retrospective analysis was conducted on 10 prostate cancer patients who had both Traditional CT and MRCAT images available. Patients underwent imaging in a consistent treatment position for both modalities with a lower immobilization device.

- Traditional CT images were acquired with Philips Ingenuity PET/CT system
- Philips Ingenia Ambition MR system generated the MRCAT (synthetic CT) images using the mDIXON sequence
- DICOM data was imported into the treatment planning system
- CT and MRCAT scans were registered
- Original proton plans were reproduced on the MRCAT scan
- Target and OAR dose distributions and clinical goals were evaluated
- DVH measurements were recorded at various dose levels for each Target and OARs
- HU were compared for all structures and across different tissue densities
- MRI-only workflow feasibility was also considered for an alternative workflow

Results

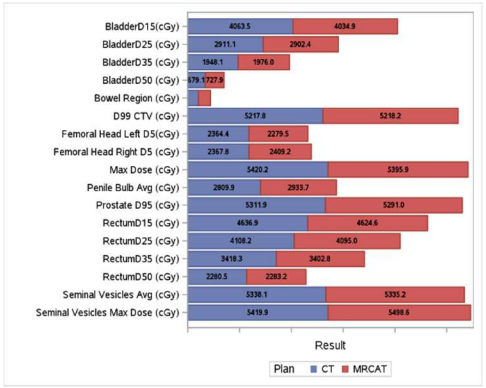


Fig. 1. The pairwise bar chart shows data from the sign(M) test evaluating the differences in dose across several structures between traditional CT and MRCAT. Statistical differences were observed in bladder D15, bowel region, left femoral head, and maximum dose.

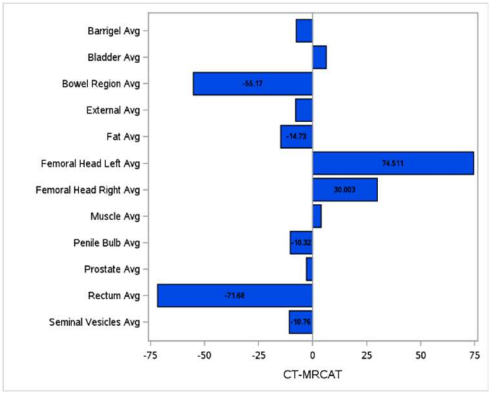
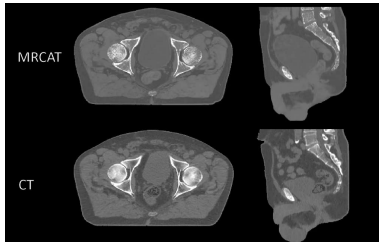


Fig 2. Image analysis was evaluated for HU accuracy for proton prostate double scatter planning on the MRCAT. Differences were noted for the rectum, bowel region, and left femoral head.



Conclusion

Most dosimetric parameters between traditional CT and MRCAT-based synthetic CT showed no significant differences for key treatment volumes, including the prostate, seminal vesicles, bladder greater than D15, and rectum. However, notable differences were observed in bladder D15, bowel region, left femoral head, and maximum dose.

Bladder and bowel dose discrepancies are likely due to organ volume changes between scans, influenced by timing and physiological filling. HU analysis revealed higher values in MRCAT for several structures, particularly the seminal vesicles, rectum, penile bulb, and bowel, often affected by air or stool presence.

MRI's superior soft tissue contrast improved delineation, but small structures like the seminal vesicles and penile bulb showed HU variability due to mixed tissue composition and shape. A consistent HU and dose discrepancy in the left femoral head vs. right was linked to a localized lower-density region, though it did not affect target coverage.

Advantages

- Eliminates registration errors
- Less ionizing radiation for the patients
- Reduces CT simulation appointments, since most proton patients receive regular verification scans for plan evaluation

Limitations

- Patient-specific contraindications for MRI, such as implanted devices
- Body habitus may impact image quality
- Treatment areas including more bowel or bladder would possibly show greater differences

References

MRCAT Pelvis MR-RT clinical application | Philips Healthcare. Philips. Accessed November 30, 2024. https://www.usa.philips.com/healthcare/product/HCNMRF266/mrcat-pelvis-mr-rt-clinical-application

Fridström KML, Winter RM, Hornik N, Almberg SS, Danielsen S, Redalen KR. Evaluation of magnetic resonance imaging derived synthetic computed tomography for proton therapy planning in prostate cancer. *Phys Imaging Radiat Oncol*. 2024;31. doi:10.1016/j.phro.2024.100625

Acknowledgments

George Spencer Arnould, Research Project Advisor
Ackerman Cancer Center, Jacksonville FL
GVSU Statistical Consulting Center
GVSU Student Funding Organization