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Quantitative T2-mapping on estimation of prostate absorbed radiation dose during radiotherapy.

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1. Background-Aim

- Prostate cancer (PCa) is the 2nd most common cancer in men worldwide. [1]
- MRI plays key roles in many steps of PCa management, including detection and diagnosis, MRI-guided biopsy, staging, active surveillance, treatment planning, evaluation of biochemical recurrence, and assessment of metastatic disease. [2]
- External Beam Radiotherapy (EBRT) serve as the primary curative-intent treatments of localized PCa, given to up to 40% of patients over 65 years old. [3,4]
- In the last decade, mpMRI has revealed a crucial role in evaluation of PCa response on external radiotherapy (RT). [3,5]
- This study was aimed to investigate the value of T2 mapping on the assessment of radiation dose effect in the prostate gland.

2. Materials & Methods

The study recruited 15 patients with biopsy-proven PCa who underwent hypo-fractionated EBRT from October 2023 to February 2023.

Table 1: Demographic data of participants

	Mean Value	Range
Gleason Score (GS)	7,00±0,88	6-9
PSA	18.47 ± 16,94 ng/ml	4,2-63,8 ng/ml
Age	74 years	68-80

Exclusion criteria: metastatic disease, previous radiotherapy in the pelvic region, previous prostate or bladder surgery for benign diseases and the presence of any metal implant near to prostate.

2. Materials & Methods

All patients performed MRI prostate exam on a 1.5T Philips manufactured (Multiva) MRI scanner prior and at the midpoint of the RT therapy using the same imaging protocol including, T2 high resolution weighted images in three planes, diffusion, T2 mapping and perfusion sequences.

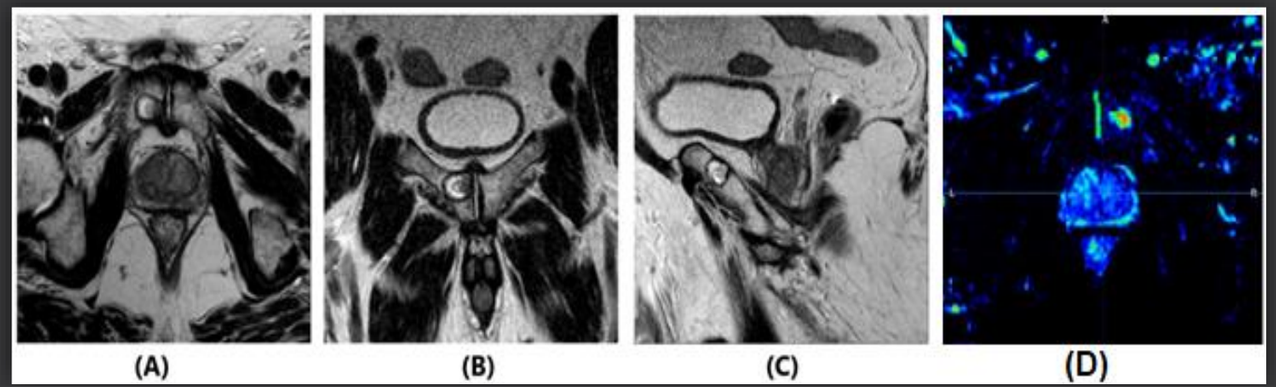

Figure 1: T2-weighted MR images in axial (A), coronal (B) and sagittal(C) planes and T2-mapping (D)

All patients were treated with Volumetric Modulated Arc Therapy (VMAT) technique using a 6MV ELEKTA InfinityTM Linear Accelerator Radiotherapy treatment plans were created using Monaco TPS version 5.11.03.

✓ Seven patients received 42,35 Gy to the prostate with 6,05 Gy/fraction for 7 days (moderate hypofractionated and accelerated HypoAR)

✓ Eight received 51,38 Gy, with 3,68 Gy/fraction for 14 days (ultra-HypoAR).

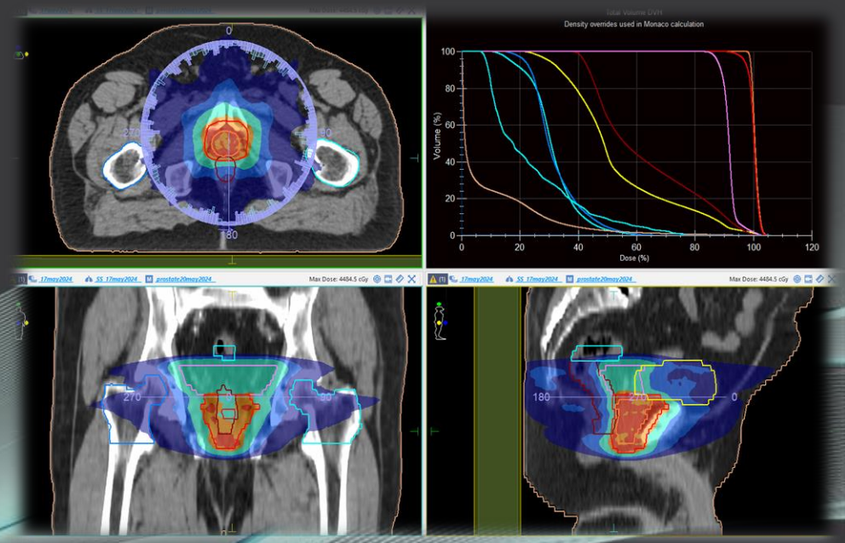

Figure 2: VMAT Treatment planning of PCa on MONACO

2. Materials & Methods

ITK-Snap software was used to segment the prostate gland T2 mapping sequences to estimate[6]:

- Volume and
- T2 relaxation time.

These parameters were estimated at both timepoints, and their longitudinal changes were calculated.

SPSS 29.0 was used to estimate their statistical differences between timepoints setting p-value lower than 0.05. [7]

At last, was studied the correlation using Pearson's Correlation Analysis the significance level to 0.05 between:

- **Normalized Signal Intensity** : $$nSI\ (ms^{-1}) = \frac{T2\_signal - Fat\_tissue\_signal}{Fat\_tissue\_signal}$$

- **Normalized Total Dose (NTD)** : $$NTD(Gy) = \frac{nd\left(1+\frac{d}{\frac{\alpha}{\beta}}\right)}{1+\frac{2}{\frac{\alpha}{\beta}}}$$

NTD according Linear Quadratic Model (LQM) n:number of fractions, d:local dose per fraction and α/β ratio for prostate (8)

3. Results

Prostate Volume

There was a significant increase ($p<0.001$)

- $Volume_{mean\text{-}midRT}$ 57,38±22,76 cm^3 compared to baseline
- $Volume_{mean\text{-}beforeRT}$ =49,32±21,21 cm^3

Figure 3 illustrates the Prostate Volume change during the RT for 15 patients.

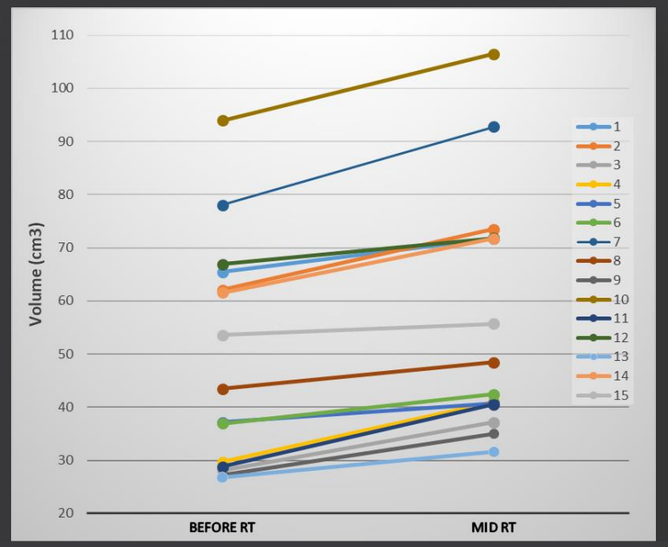

Figure 3: Prostate Volume Changes prior and mid RT sessions.

T2 mapping

T2 Relaxation time on prostate gland was significantly ($p<0,001$) higher

- midpoint $T2_{mean}$=108,46±11,58 msec than
- baseline $T2_{mean}$=101,45±19,92 msec

Figure 4 illustrates the longitudinal T2WI changes between RT sessions.

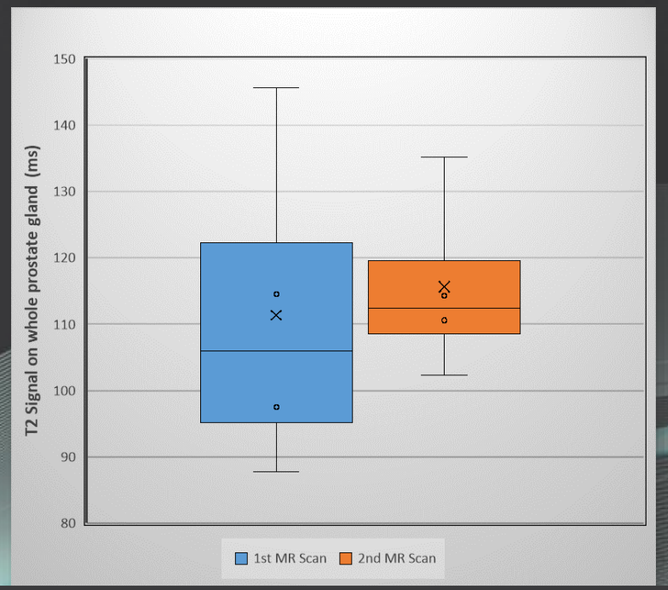

Figure 4: T2WI changes between two RT sessions.

3. Results

NTDose – MR nSI correlation

Regression Analysis revealed the below linear correlation between nSI(ms^{-1}) and NTD(Gy).

$$nSI\ (ms^{-1}) = 29,79 + 9,77 * NTD\ (Gy)$$ (F(1,12)=8,067, p-value=0,016)

Figure 5 validated the linearity between mSI (ms^{-1}) and NTD(Gy).

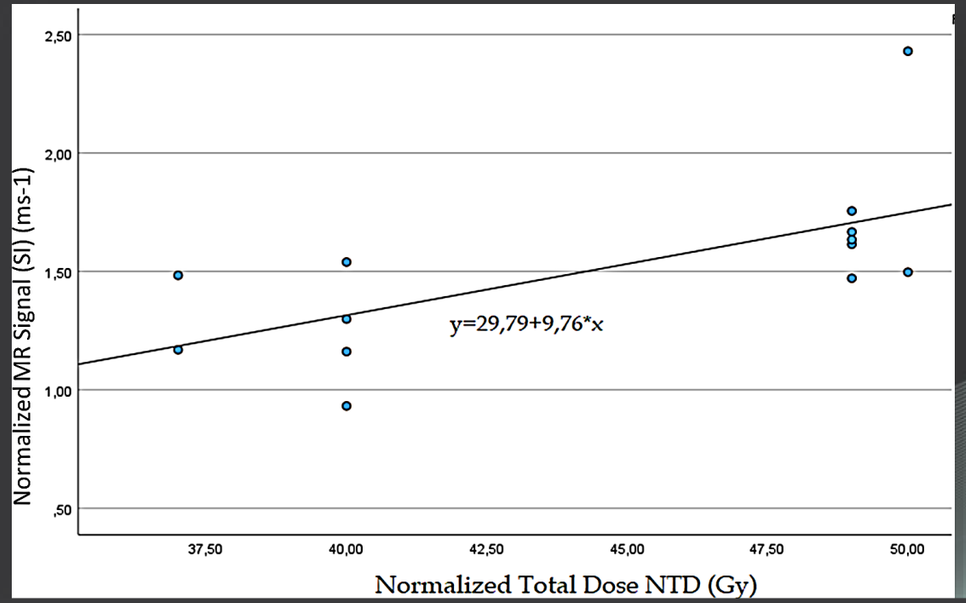

Figure 5: Plot of Regression Analysis between nSI(ms-1) and NTD(Gy).

4. Conclusions

- T2 relaxation time could be a valuable imaging biomarker to estimate the delivered radiation dose on the prostate gland during radiotherapy.

- A significant result comprises the increase of prostate gland volume during the RT since it might be considered in the PTV planning.

- MRI seems to provide useful imaging markers to improve prostate RT effectiveness

- Improvements and standardization of methods are necessary.

5. References

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