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EASTERN TIME [GMT-4]

Inter-scanner T1 and T2 mapping evaluation using multiple MRI phantoms at 3T

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MAYO CLINIC

INTRODUCTION

- The sensitivity of quantitative MRI (qMRI) to subtle imaging biomarkers enables detection and staging of disease more precisely than standard anatomical imaging alone. (1)
- The continuing development of precision medicine practice is dependent on the accuracy and precision of qMRI methods such as T1 and T2 mapping.
- Performing mapping on dedicated T1 and T2 phantoms allows for verification of qMRI pulse sequences for accuracy. (2)
- Standard phantoms like the NIST qMRI phantom and specialized phantoms like the prostate qMRI phantom contain inserts of varied T1/T2 solutions that mimic physiological values.

AIM

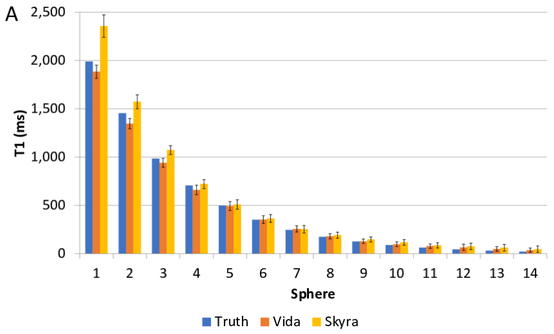
- To estimate the variability and accuracy of T1 and T2 mapping using MRI phantoms with known T1 and T2 values on Siemens MRI platforms.

METHOD

- A prostate qMRI and a NIST system phantom were scanned on Siemens 3T Vida and Skyra MRI scanners with a 30-channel body coil.
  - The prostate phantom had 6 T1/T2 inserts: T1 range 126-1989ms, T2 range 32-278ms
  - The NIST phantom had 14 T1/T2 inserts: T1 range 22-1989ms, T2 range 6-581ms
- T1/T2 mapping was performed using built-in clinical T1/T2 mapping sequences
  - T2 mapping used spin-echo multi-contrast (SE-MC), TE 10.5ms,
    - For T2 mapping the number of echoes was varied between 6 (default), 15, and 30. TR ranged from 2200-5500ms.
  - T1 mapping used turbo spin-echo inversion recovery (TSE-IR), TR 4.66ms, TE 1.78, FOV 220x220mm, slice thickness 3mm, resolution 192x154.
- Axial slices were acquired through the center of the T1/T2 spheres, and circular ROIs were placed within each sphere. Average and standard deviation were recorded for each ROI.
- Image analysis was performed in Siemens Syngo.via. Figures were created in Microsoft Excel.

RESULTS & DISCUSSION

A



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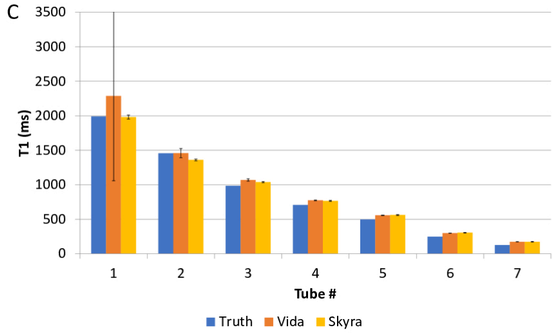

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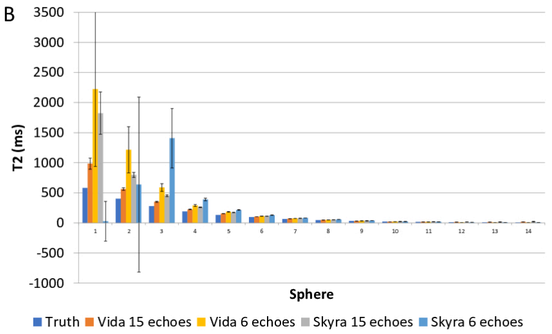

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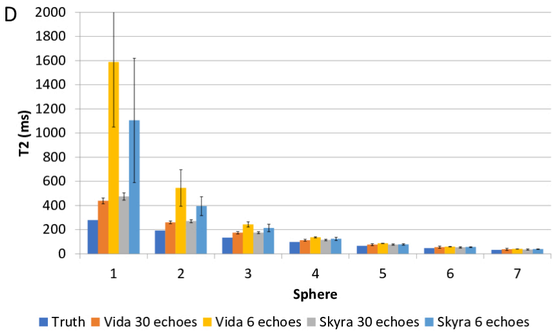

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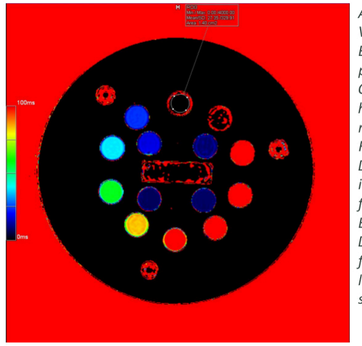

A: NIST Phantom T1 data. Both Skyra and Vida data are fairly accurate
B: NIST Phantom T2 data. 15 echoes performed better than 6 echoes
C: Prostate Phantom T1 data. Vida Tube 1 had problems with image reconstruction resulting in large uncertainty within that ROI.
D: Prostate Phantom T2 data. Again increasing the number of echoes acquired from 6 improves data accuracy.
E: Example T2 map with ROI over insert. Demonstrated is the image reconstruction failure in the T1/T2 maps for longer values, leading to loss of data and high measured standard deviation within the ROI.

- T1 measurements were fairly accurate on both the Skyra and Vida
  - Standard deviation of pixel values within ROI was very tight, with one exception in the Vida prostate phantom data possibly due to T1 map reconstruction errors.
  - T1 measurements for low T1 values were slightly overestimated on both phantoms
  - The NIST phantom had the greatest % error on inserts with <15ms T1s.
- T2 measurement accuracy decreases markedly as the T2 value of the solution goes above ~150ms.
  - Increasing the number of echoes improves the accuracy and precision of the T2 mapping, but still did not bring the measured values to <10% of the T2 values listed in the phantom technical data.
  - This shows the T2 decay curve is not sufficiently sampled with only 6 echoes.
  - Using 30 echoes on the NIST phantom was not as accurate as 15 echoes; 30 echoes may be overfitting the data, especially for lower T2 values.
- Image reconstruction errors like in Figure E commonly occurred in inserts with the longest T2 values, indicating the acquisition sequence can use further optimization.

CONCLUSIONS

- The variability of measurements of T1 and particularly T2 indicates that accuracy and reproducibility of quantitative MRI is highly dependent on pulse sequence parameters, such as the number of echoes acquired, even when scanning standardized phantoms.
- Further optimizations to the pulse sequence may improve mapping accuracy, particularly for the very high/low T_1/T_2 values.
  - An example would be controlling echo spacing in T2 mapping to allow for more dense sampling of the T2 magnetization near the beginning of the decay curve.

REFERENCES

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CONFLICTS OF INTEREST

The authors have no conflicts of interest to declare.

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