Evaluation of a stepped TE segmented EPI sequence for Relaxometry Based MR Gel Dosimetry at 1.5T and 3T.

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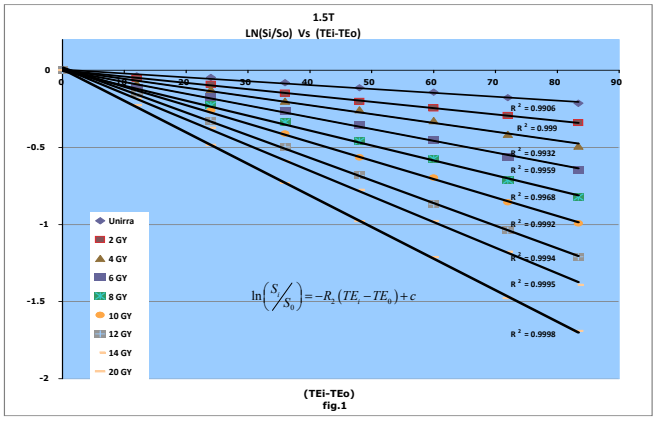
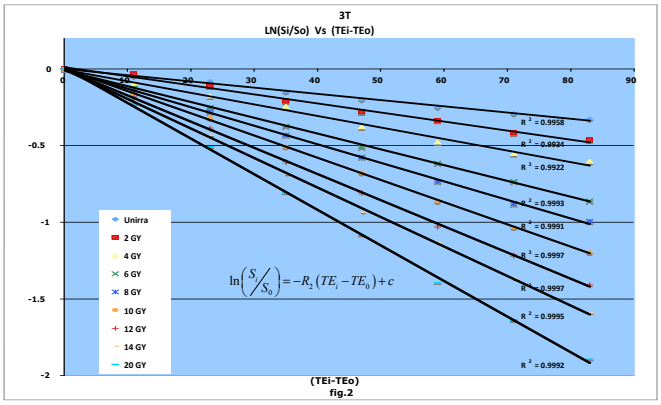
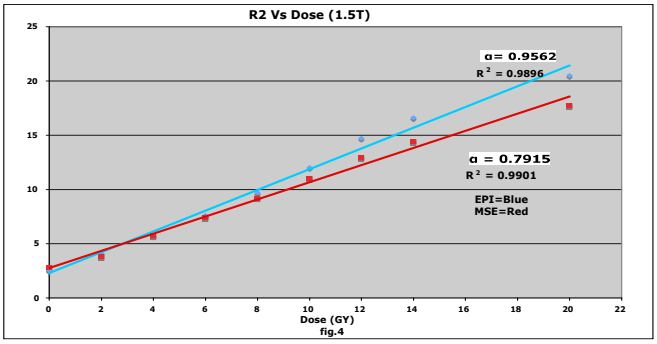
Problem: Accurate 3D dosimetric mapping is challenging but critical for the verification of a large range of treatment plans. MR based Relaxometry mapping of radiation sensitive gels has been investigated for dose mapping. The multiple spin echo sequence has been evaluated as the most time efficient sequence which also enables accurate T2 mapping across the dynamic range of T2 values encountered in a treatment map. However MSE sequences are long and are susceptible to signal corruption from multiple pathways, imperfect 180^0 pulses, and may result in sample heating from multiple 180^0 pulses. Faster pulse sequences based on FSE or its variants (TGSE) suffer from problems similar to that of the MSE sequences. Our aim was to evaluate a segmented echo planar imaging sequence with stepped TE for 3D dose monitoring using a 1.5T and 3T scanner;

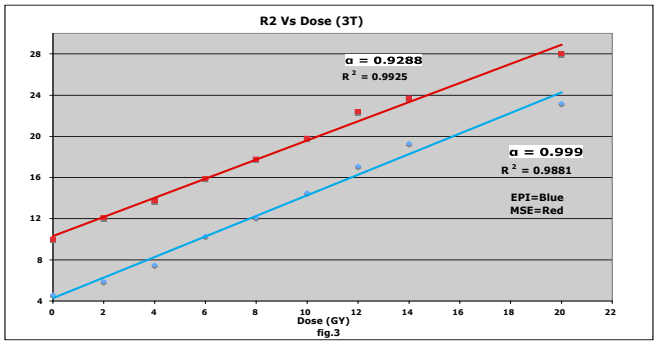
Methods: The polymer gel (BANG KIT, MGS Research) was prepared under normoxic conditions and stored in glass vials. Calibration was performed under dose range of 3-18 Gy with irradiation using the True Beam. Segmented Echo Planar Imaging Sequence was evaluated for T2 relaxometry at 1.5T and 3T (GE medical systems). The parameters of the stepped TE segmented Echo Planar Imaging Sequence were kept identical at both 1.5 and 3T: TE=15.6,27,39,51,63,75,87,99 ms; TR= 4000ms; FOV=22*22;Slice thk/gap: 3/3; # Shots=14; Scan time=8 min. The MSE sequence parameters were set close to the EPI sequence on both scanners (scan time: 18 mins).

Results: The EPI image quality at 1.5 T was comparable to the MSE sequence; at 3T ghosting artifacts could be seen in the EPI images. The log linear plot of signal intensities of the segmented EPI sequence for irradiation in the range 0-20 Gy is shown at 1.5 and 3T (fig 1 & 2) .The T2 values agreed with that of corresponding MSE sequences at both 1.5 and 3Tand the fit was much better using the segmented EPI sequence than the MSE sequences. The dose calibration factor,α, was similar for all the sequences (fig. 3- 3T α: MSE=0.93, EPI=0.99 ; fig.4- 1.5T α: MSE=0.79, EPI=0.95)









Discussion & Conclusion: A single shot EPI sequence introduces bias in T2 relaxometry since the acquisition window can be as long as 100 ms to enable collection of all echoes. However, the 14 shot EPI has an acquisition window of 10 ms, low compared to even the lowest T2 gel (49ms irradiated with 20Gy); this is verified by the log-linear relationship at all T2s (Fig. 1,2) . The EPI sequence enables the acquisition to be completed in less than half the time of the MSE sequence while allowing more flexibility in the choice of TEs (e.g., uneven spacing). There are discrepancies in the T2 values of the gel obtained at the two fields; some of this can be attributed to the fact that the gel was scanned at 3T a week after the 1.5T scan. It is known that oxygen contamination can bias gel values and may have contributed to the difference. The maximum discrepancy in T2 values was seen with the MSE sequence. This may arise from imperfect 180^0 pulses at 3T. However, despite baseline shifts of T2 (R2), the dose calibration factor at 1.5 and 3T was similar for the EPI sequence. The study establishes the stepped TE segmented EPI as a novel sequence for dose mapping at 1.5T and at 3 T.