

Purpose:To investigate the feasibility of using MRI to verify proton beam range in distal regions for liver tumor treatment.

Methods:In the treatment of liver tumors with proton beams, the dose range uncertainty in the distal region can lead to reduced dose in tumor and/or increased dose in the surrounding normal tissue. Due to the increased extracellular fluid after radiation treatment, the irradiated areas in liver usually appear hypo-intense on T1-weighted MR images, and hyper-intense on T2-weighted MR images. This change of MR signal intensity (SI) allows for a quantitative verification of dose range in vivo. To achieve this goal, follow-up T1/T2-weighted MR images are firstly registered to the planning CT images. Then MR SI is correlated to the radiation dose at the superior/inferior penumbra dose fall-off, which includes two penumbrae in two proton beams. This SI-dose correlation is finally employed on MR images to estimate the proton end-of-range. This methodology is being evaluated on a 15-patients database, which is being collected in our institute.

Results:The preliminary results were based on three patients who received proton liver treatment. We observed correlations between MR SI and radiation proton dose in superior/inferior penumbra regions, with correlation coefficients (R^2) of 0.86, 0.97, and 0.97, respectively. By applying the SI-dose correlation to the distal region of proton beam, the mean distances from the MRI-estimated dose range to the prescribed dose range were -0.4 mm, 2.6 mm, and 2.4 mm, respectively.

Conclusions:The preliminary results demonstrate that the proton dose range can be verified in vivo to within 2.6 mm by follow-up MR images after proton liver treatment. This IRB-approved study is being extended to 15 patients with liver cancer treated by proton radiotherapy.