Purpose: To correct for quenching on a voxel-by-voxel basis for proton pencil beams in a liquid scintillation dosimetry system.

Methods: Scintillation light from a proton pencil beam in a tank of organic liquid scintillator (20x20x20 cm3) was measured with a CCD camera for three beam energies (100.9, 144.9, and 161.6 MeV). Three-dimensional dose and linear energy transfer (LET) distributions were calculated for each beam energy using a validated Monte Carlo model of the proton pencil beam. The quenching for each voxel in the scintillator was calculated using the LET and material-specific empirical factors. The empirical factors for the scintillator were obtained by a fit to the Monte Carlo LET and dose data and the intensity values measured with the CCD camera for the central energy (144.9 MeV). The empirical values and Monte Carlo calculations were then used to predict the quenched light signal for the other two proton energies. The differences between the predicted and measured light signals were quantified using a gamma index of 3% or 3mm to agreement.

Results: The LET in the distal falloff region was a factor of 10 higher than in the proximal build-up region, while the measured light peak was 75% of the Bragg peak height. The calculated light signal derived from the voxelized quenching factors provided a good approximation of the measured light signal.

Conclusion: The results of this study indicate that it is possible to correct for scintillator quenching on a voxel-by-voxel basis in a large detection volume. This correction requires a prior knowledge of the three-dimensional LET distribution of the beam and the material-dependent empirical quenching factors for the scintillator. This quenching correction method will be employed in future studies using liquid scintillators to obtain three-dimensional dosimetric information from proton pencil beams.