

Purpose: IMRT delivery could be affected by residual target motion, the intrafractional target uncertainties resulting from motion that follows image-guided procedures such as dual x-ray image acquisitions with patient positional corrections. This study investigates the 6D spatial characteristics of residual target motion and a method for minimizing potential IMRT delivery errors.

Method and Materials: A recursive dose painting algorithm was developed to reorder MLC segments, so that most segments were delivered repetitively at a fraction of its prescribed MU. The rationale is that there could be residual target motion that would cause significant delivery errors, so to “paint” the target voxels recursively in small dose segments instead of painting the whole area once with a larger dose segment, could produce a more accurate delivery. The residual target motions used were determined from implanted spine fiducials detected using the dual x-ray images taken every 10-20 seconds during treatment (Cyberknife, Accuray). Six-degree of freedom spatial characteristics of the residual target uncertainties were extracted. These residual motions were then fed into the recursive dose painting method for dose evaluation.

Results: The residual target motion study showed that although the average was less than 3 mm during the whole delivery, there existed large irregularities in distributions in both rotational and translational directions. For most cases, there were also systematic motion errors of 0.5-1 mm and large spurious motions, sometimes of 5 mm or more. When using the actual error-time curves, the recursive delivery significantly reduced dose variations caused by such errors (by as much as 27%). For the majority of cases studied, a cycle of three to six repetitive dose paintings was found sufficient to achieve such improvements.

Conclusion: Residual target motion is irregularly distributed as treatment time progresses. Recursive dose painting provides a solution to decrease the dose errors caused by such uncertainties.