Analysis of Migration of Implanted Markers for Image-Guided Lung Tumor Stereotactic Ablative Radiotherapy

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Purpose/Objective(s): To evaluate the post-implantation migration of percutaneously placed fiducial markers for tumor-tracking in stereotactic ablative radiotherapy (SABR) of pulmonary tumors, and compare the migration of two marker types: smooth cylindrical gold seeds (“seeds”) and platinum endovascular embolization coils (“coils”).

Materials/Methods: With institutional review board approval, we retrospectively analyzed the migration of percutaneously implanted markers in 32 consecutive patients who had computed tomography (CT) scans both immediately post-implantation and at simulation between January 2004 and June 2009. 147 markers (59 seeds, 88 coils) were implanted in or around 34 pulmonary tumors over 32 procedures, with one lesion implanted twice. Markers were implanted under CT guidance. Marker coordinates from post-implantation and simulation CT scans were aligned by translation and rotation by minimizing fiducial registration error (FRE), the root mean square of the differences in marker locations for a given tumor between the two time points. Alignment was performed with and without exclusion of the outlier in each group of markers causing the largest increase in FRE to evaluate if error was disproportionately attributable to migration of a single marker. We evaluated migration of individual markers as well as the FRE of each group of markers, and compared this across marker types.

Results: Median time between implantation and simulation was 8 days (range 5-248 days). Results are reported per lesion and per marker. Median individual marker migration was 1.3 mm, 1.5 and 1.2 mm for seeds and coils, respectively. Median FRE across lesions was 1.6 mm, 1.9 and 1.3 mm for seeds and coils, respectively. Interquartile (25-75%-ile) range of FRE was 0.9-3 mm. The corresponding values when aligning with outlier exclusion were 1.0 mm median individual marker migration (0.7 for seeds, 1.2 for coils) and 2 mm median FRE (1.7 for seeds, 2.1 for coils). The differences between seeds and coils were not statistically significant. Of note, this analysis does not exclude the possibility that some of the apparent migration was due to breathing-induced tissue deformation.

Conclusions: We previously reported that retention of implanted markers is significantly higher for coils compared to seeds. This analysis suggests that once retained, further marker migration is of small magnitude between the times of implantation and simulation, regardless of marker type. When tracking tumors by markers, marker migration appears unlikely to result in geometric miss.