

Purpose

There has been recent interest in gold nanoparticles as vascular disruptive agents when combined with megavoltage x-ray irradiation. In addition to the therapeutic benefits, the gold nanoparticles may also have a role as an alternative to implanted fiducials for improving localization for IGRT and real-time tumor tracking. We demonstrate the feasibility of tracking a gold nanoparticle solution of moderate concentration with kV x-ray fluoroscopy.

Methods

A 2.0 mg/ml solution of polymer coated gold nanoparticles was injected into 0.5 cm clinical bolus material. Additional build up with solid water was used to create a more realistic radiological scenario. A cylindrical gold fiducial (3 mm x 1 mm) was placed nearby to act as a reference surrogate. The phantom was set in sinusoidal motion with 2 cm amplitude and 4.0 s period. Images were acquired at 30 frames/sec with the kV on-board imaging system of a Varian IX Clinac. The ratio of the image intensity in each target versus background was measured. Target tracking was performed using a single template matching approach and non-clinical research software. Tracking error was quantified as the difference in location of each track point from the input sine function.

Results

The intensity ratio in a single image of a sequence was 1.3 for the gold fiducial and 1.2 for the 2.0 mg/ml gold nanoparticle solution. Tracking was maintained throughout the 25 seconds of target motion. RMS tracking error was 0.4 mm for the gold fiducial and 0.6 mm for the gold nanoparticles. The tracking score was smaller for the nanoparticles (mean: 0.63 0.02) than for the fiducial (mean: 0.89 0.6).

Conclusions

Target tracking in kV fluoroscopy can be enabled by gold nanoparticles. A solution of 2.0 mg/ml can be tracked in a phantom with an accuracy similar to tracking a gold fiducial.