AbstractID: 2896 Title: Dynamic Accuracy of an Implanted Wireless AC Electromagnetic Sensor for Guided Radiation Therapy; Implications for Real-Time Tumor Position Tracking

Purpose:
A wireless tumor localization and tracking system using three implanted AC electromagnetic transponders is in clinical trials for use in prostate cancer (Calypso® Medical). Phantom-based studies have shown sub-millimeter spatial localization accuracy in static tests. Accuracy has not been evaluated for dynamic motion found in lung tumors. This study was designed to determine the feasibility of using this patient positioning system for real-time tumor-tracking.

Materials and Methods
A 4-dimensional (4D) stage capable of arbitrary multidimensional motion with speeds up to 10 cm/sec was constructed. Two elliptical trajectory paths were created with peak-to-peak motion of 1cm x 2cm x 1cm and 2cm x 4cm x 2cm in the x, y and z directions. Each trajectory was operated with periods of 15 - 20 cycles per minute. The Calypso System was operated using one and two transponders with radiofrequency signal integration times of 33 ms 100 ms. The transponders were mounted on the 4D-stage, with the ellipse centroids positioned 14 cm from the array. The effects of ellipse size, speed, number of transponders and signal integration time on transponder localization accuracy were evaluated by comparing the intended and measured trajectories.

Results
The root mean square (RMS) position difference was less than 1 mm for all tested combinations. While small, the RMS error was largest for the large ellipse at 20 cycles per minute compared with the small ellipse at 15 cycles per minute. The single-transponder system with 67 ms integration time had the smallest overall error, with a maximum single-point error of 1.3mm.

Conclusions
Use of a wireless electromagnetic implanted transponder system for real-time tumor-tracking is feasible, with RMS errors less than 1mm for high-speed multidimensional ellipses. This compares favorably with continuous fluoroscopic tracking methods without an ionizing radiation burden. This work is currently being expanded to patient-derived tumor trajectories.