AbstractID: 5391 Title: Performance Evaluation and Optimization of a Novel Brachytherapy Robot

Purpose: To evaluate and optimize the performance of a prototype robotic manipulator designed for prostate seed implantations in a gel phantom.

Methods and Materials: The prototype design is a custom-built six degree-of-freedom robot engineered for highly accurate prostate seed implantations. The robot allows for a fully automatic insertion or a manually assisted implantation using the device as a guide. The accuracy was determined using a gel phantom with a holed-template placed at 10 cm depth. Insertion speed and rotation were varied, and the distance from the target hole was measured. The effect on the gel due to needle rotation was observed for increased damage. The experiment included both manual and automatic insertions using 30 cm, 17-gauge, beveled-tip prostate brachytherapy needles.

Results: The optimal techniques were automatic insertions with a rotation speed of 10 rev/s or 1 rev/s. This provided a "hit" of the target 67% of the insertions with maximum displacement in the "non-hit" insertions of 2.1 mm. The least accurate technique utilized a non-rotated needle, which deflects towards its beveled-tip as inserted. The total displacement from the target with this technique reached distances of greater than 8 mm for a 10 cm depth insertion with an average of 6.9 ± 0.8 mm.

Conclusion: Preliminary results yielded an optimization of insertion parameters which increased the accuracy from near 1 cm to sub-millimeter displacements. The robot was determined to have a high accuracy in tip placement within the gel. Rotation of the needle can dramatically increase the accuracy of the tip's final position. Rotating the needle at 1 rev/s yielded an accurate implant with minimal increase in gel damage. The robot used in conjunction with an optimized needle insertion technique benefits the patient with increased accuracy, leading to a more successful outcome and reduced complications.