An efficient optimization method for prostate LDR planning by including prior knowledge

G. SZALKOWSKI[1], R. CHEN[2], A. WANG[1], T. ROYCE[1], J. LIAN[1]
(1) University of North Carolina at Chapel Hill, Chapel Hill, NC
(2) University Of Kansas, Lawrence, KS

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INTRODUCTION

Low dose rate (LDR) brachytherapy remains one of the main treatment modalities for prostate cancer. Of the methods used to administer this treatment, real time planning allows for the most adaptive delivery [1,2.] However, this method requires more time than other techiques, increasing the time when the patient is under anesthesia, and puts more pressure on the planner, which can lead to suboptimal plans.

AIM

We aim to use prior knowledge gained from a library of past plans to increase the efficiency of our workflow by:

- Increasing the quality of the initial plans provided by the software, requiring less modification by the planner, and
- Decreasing the number of needles and sources used in the final plan while meeting the same dosimetric goals to reduce the delivery time and physical trauma to the patient

METHOD

By analyzing our library of past plans, we identified areas where the initially plans generated by our treatment planning system (VariSeed, Varian Medical Systems, Palo Alto, CA). These included proximity of needles to the urethra and/or rectum, and the shape of the 150% isodose line. We created two standardized optimization structures, an asymmetric expansion of the urethra and a shell around the prostate, as well as a new optimization function template to push the optimizer to create improved initial plans. Along with this, we created a new optimization function template Ten patients were then retrospectively planned using the current and newly developed methods, and the number of modifications (addition/subtraction of a needle or source) needed to make each initial plan clinically deliverable was recorded. The total number of needles and sources used was also compared between the plans generated with the optimized method and those that were actually clinically delivered.

RESULTS

Compared to the method currently used clinically, the new optimized workflow resulted in:

- an average **75.7±19.7%** reduction in the number of needle modifications from the initially generated to clinical plan
- an average **89.6±10.6%** reduction in source modifications from the initially generated to clinical plan
- on average **10.9±8.4%** fewer needles in the final plan
- on average **13.1±3.8%** fewer sources in the final plan

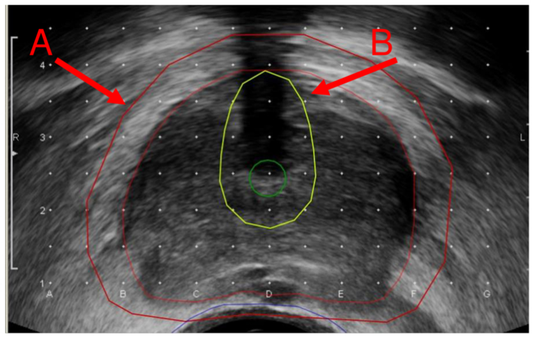

Figure 1: Illustration of the prostate shell (A) and expanded urethra (B) optimization structures used in the new method. The prostate shell helps push the normal tissue dose fall-off and assures that the optimizor does not place seeds outside of the prostate. The expanded urethra helps shape the 150% isodose line and prevents the placement of needles close to the path of the urethra.

Table 1: Needle and source modifications needed for the current clinical and optimized workflows. The reduction was calculated on a case-by-case basis. Median is reported due to the large variation in needles and sources used across patients

	Needles Modified			Sources Modified		
	Clinical	Optimized	Reduction	Clinical	Optimized	Reduction
Median	17	3	**-13**	12.5	1	**-9.5**
Std Dev	5.3	3.5	**5.5**	3.7	1.1	**3.9**

Table 2: Total needles and sources used in the final plans for the clinical and optimized workflows. As above, the reduction was calculated on a case-by-case basis and median is used due to the large variation between cases.

	Needles Used			Sources Used		
	Clinical	Optimized	Reduction	Clinical	Optimized	Reduction
Median	16.5	14	**-2.5**	47	41	**-6**
Std Dev	3.2	3.4	**1.5**	12.8	11.1	**2.8**

CONCLUSIONS

The optimized workflow presented here provides a substantial improvement over our current clinical practice, both in patient safety, by reducing time under anesthesia and reducing the number of implantations, and in clinical resources. Further work will be done to continue to streamline the process and evaluate other areas of improvement as the new workflow is phased into clinical practice.

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CONTACT INFORMATION

Gregory Szalkowski: gregory.szalkowski@unchealth.unc.edu
Jun Lian: jun_lian@med.unc.edu