Dosimetric comparison of graphical optimization and inverse planning simulated annealing in Oncentra TPS based MUPIT interstitial plans

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INTRODUCTION

Delivering very high dose to the target being the primary goal of HDR brachytherapy, sparing the normal organs is equally important. Graphical optimization (GRO) provides an interactive way for the user to manually manipulate dose distribution by shifting the isodose curves. In Oncentra treatment planning system, inverse planning by simulated annealing (IPSA) is an anatomy-based optimization which optimizes the source dwell timings using simulated annealing.

AIM

To dosimetrically compare the GRO and IPSA planning methods in Oncentra brachytherapy treatment planning system on gynecological interstitial cases using MUPIT applicator.

METHOD

Eight gynecological tumor plans previously treated on a Nucleotron remote afterloader using Martinez Universal Perineal Interstitial Template (MUPIT) applicator was selected in this study. GRO and IPSA-optimized treatment plans were created from the delivered plan. In IPSA optimization, variance of dwell times in a single catheter resulting in hot spot at the extremities of the catheter have been published. Control of dwell time variance within each catheter is controlled with dwell time deviation constraint (DTDC). Three IPSA plans with no, with some and with maximum control of variance of dwell time were created using three values of the DTDC=0, 0.5, and 1.0, respectively.

IMAGE FUSION: CT simulation was performed on a Philips BigBore Brilliance scanner and images were reconstructed at 1 mm slice spacing. Importing the CT slices into Oncentra TPS, the physician performs contouring of Clinical target volume (CTV), bladder, rectum, and sigmoid.

TREATMENT PLANNING: Both planning methods followed American Brachytherapy Society's 2015 Consensus statement for medically inoperable endometrial cancer on prescription and normal tissue dose constraints. The intention was to achieve brachytherapy equivalent dose in 2-Gy fraction (EQD2) to 90% target volume (D90%) of atleast 48 Gy for prescription dose (Rx) of 5 Gy over 5 fractions. Dose objectives include a maximum tolerable dose to 2 cc volume (D2cc) of OARs (including rectum, bladder, sigmoid). Based on external beam Rx dose of 45 Gy, Brachytherapy EQD2 of CTV>31.8 Gy, D2cc bladder <100 Gy, rectum < 75 Gy, sigmoid < 75 Gy were derived from ABS guidelines. Additionally, several other plan evaluation metrics including percent volume coverage by 100%, 150%, and 200% of Rx, percent dose irradiating 50%, 90%, and 100% of target volume, dose conformity index, total dwell timings, and time for plan generation.

Wilcoxon signed-rank test was used to ascertain significant differences at p-value<0.05.

RESULTS

Eight gynecological tumor cases using a MUPIT interstitial applicator were analyzed. Volumes of CTV ranged from 33 cc to 189 cc (mean±SD =78±49 cc) were re-planned. Dose distribution of the IPSA and GRO optimized plans were shown in Figure 1.

There were also no significant differences in dosimetry between GRO and IPSA based on target coverage, dose conformity, and isodose distributions with a few exceptions. With regard to OAR dose constraints to D2cc, rectum had failed on all four types of plans on one patient. The number of plans beyond tolerance on D2cc of bladder, rectum in GRO but not on IPSA plans were 3 and 2 respectively. The IPSA plan had significantly smaller 200% hotspot volume (V200%) than GRO plans. Significant reductions in total dwell time and number of dwells can be observed using IPSA. On average, total dwell times and number of dwell positions were lower by 10% and 5.9% on IPSA calculated using DTDC=0.0 than GRO plans, respectively. In addition, GRO planning times were longer by 9.6% than IPSA computed plans. For this reason, IPSA makes for a useful planning tool for gynecological interstitial brachytherapy.

The volume of hotspots (V200%), the mean dwell times and the planning times were significantly lower in any IPSA computation compared to the GRO plans (p-value<0.05).

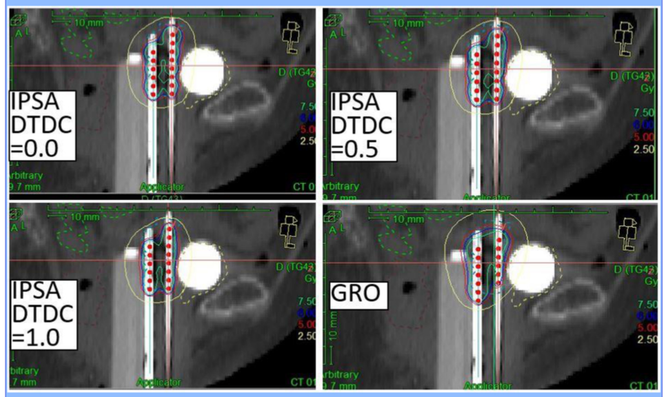

Figure 1. *Dose distributions on a sagittal plane of IPSA (DTDC=0, 0.5, and 1) and GRO plans on a representative patient with a MUPIT interstitial applicator.*

Metrics	GRO	IPSA (DTDC=0)	IPSA (DTDC=0.5)	IPSA (DTDC=1)
D100% (%)	48±9	47±10	44±10	41±9
V100% (%)	80±7	80±8	79±7	78±7
V150% (%)	45±14	39±12	39±12	41±13
V200% (%)	24±10	15±6*	16±6*,+	17±7*
CI	1.5±0.1	1.5±0.1	1.5±0.1	1.5±0.1
D2cc (Gy) Bladder	3.2±0.4	3±0.1	3±0.2	3±0.2
D2cc (Gy) Rectum	2.3±0.7	2.1±0.5	2.1±0.5	2.2±0.5
D2cc (Gy) Sigmoid	1.1±0.7	1±0.5	1±0.5	0.9±0.5
Dwell Times (sec)	87±50	187±70*	185±69*	180±61*
Plan Time (min)	14±6	4.3±1.4*	3.9±1.9*	4.1±0.8*

Table 1: Dosimetric evaluation metrics (mean±SD) in the GRO and IPSA (DTDC=0, 0.5, and 1.0) plans. Note *,+ indicates statistically significant differences with GRO, IPSA (DTDC=0) plans respectively.

CONCLUSIONS

Both GRO and IPSA computed plans using a MUPIT interstitial brachytherapy applicator produced plans which met the dose objectives. Although the plans were equivalent on many counts, IPSA-optimized plans had significantly smaller volume of hotspots, used lower dwell times, and took less time to plan.

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