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FULL PAPER

A dosimetric comparison of RapidArc and IMRT with hypofractionated simultaneous integrated boost to the prostate for treatment of prostate cancer

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Objective: To compare the dosimetric results and treatment delivery efficiency among RapidArc® (Varian Medical Systems, Palo Alto, CA), 7-field intensity-modulated radiotherapy (7-f IMRT) and 9-field IMRT (9-f IMRT) with hypofractionated simultaneous integrated boost to the prostate.

Methods: RapidArc, 7-f IMRT and 9-f IMRT plans were created for 21 consecutive patients treated for high-risk prostate cancer using the Eclipse™ treatment planning system (Varian Medical Systems). All plans were designed to deliver 70.0 Gy in 28 fractions to the prostate planning target volume (PTV) while simultaneously delivering 50.4 Gy in 28 fractions to the pelvic nodal PTV. Target coverage and sparing of organs at risk (OARs) were compared across techniques. The total number of monitor units (MUs) and the treatment time were used to assess treatment delivery efficiency.

Results: RapidArc resulted in slightly superior conformity and homogeneity of prostate PTV, whereas all plans were comparable with respect to dose to the nodal PTV. Although OARs sparing for RapidArc and 7-f IMRT plans were almost equivalent, 9-f IMRT achieved better sparing of the rectum and bladder than RapidArc and 7-f IMRT. RapidArc provided the highest treatment delivery efficiency with the lowest MUs and shortest treatment time.

Conclusion: RapidArc resulted in similar OAR sparing to 7-f IMRT, whereas 9-f IMRT provided the best OAR sparing. Treatment delivery efficiency is significantly higher for RapidArc.

Advances in knowledge: This study validated the feasibility and limitations of RapidArc in the treatment of high-risk prostate cancer with complex pelvic target volumes.

Radiotherapy has played an important role in the treatment of locally advanced prostate cancer. Several randomised controlled trials have demonstrated that high-dose radiotherapy improves prostate-specific antigen control, and a recently published meta-analysis [1] showed that high-dose radiotherapy is superior to conventional-dose radiotherapy in preventing biochemical or clinical failure and prostate cancer-specific death. However, dose escalation has been limited by toxicity in conventional techniques. Therefore, prostate cancer is one of the most common tumour sites treated with intensity-modulated radiation therapy (IMRT), which enables the delivery of highly conformal dose distribution to the target while reducing the dose to critical organs. IMRT also has the ability to produce inhomogeneous dose distribution, which allows for simultaneous differential dose delivery to multiple tumour targets (simultaneous integrated boost). Despite the obvious benefits of IMRT, there are some disadvantages. The potential downsides of IMRT include the increased time required for radiotherapy delivery

and increased monitor units (MUs) needed compared with conventional three-dimensional conformal radiation therapy.

Volumetric-modulated arc therapy (VMAT) is a relatively new rotational radiation therapy technique based on the idea of delivering IMRT with continuous dynamic modulation of the dose rate, field aperture and gantry speed. Compared with IMRT, the potential benefit of VMAT is the increase in delivery efficiency, including a shorter treatment time and a lower number of MUs.

Several recent studies have compared VMAT with IMRT for prostate radiotherapy [2–13]. Although shortened treatment time is a common finding, there are inconsistencies in the dosimetric outcome. Many studies considering relatively simple target volumes that included prostate only or prostate with seminal vesicles found that VMAT achieved equal or better normal tissue sparing over IMRT [2,3,5,6,8–10,12]. However, very few studies have focused

on more complex pelvic target volumes, including the prostate, seminal vesicles and pelvic lymph nodes [4,7,11,13]. Some of these studies found largely equivalent sparing of organs at risk (OARs) between VMAT and IMRT [7,13]. However, other planning studies have reported contradictory results. Yoo et al [4] noted superior OARs sparing with IMRT to VMAT. Myrehaug et al [11] found VMAT to have no consistent dosimetric advantage over IMRT. Thus, those studies have yielded mixed results. Our study aims to expand such studies to quantitatively evaluate VMAT for prostate cancer cases with complex pelvic target volumes and simultaneous integrated boost techniques.

RapidArc® is one of the VMAT techniques implementing the progressive resolution optimisation algorithm in the Eclipse™ planning system by Varian Medical Systems (Palo Alto, CA). In the present study, we compare the performance of RapidArc, 7-field IMRT (7-f IMRT) and 9-field IMRT (9-f IMRT) with hypofractionated simultaneous integrated boost to the prostate for patients with high-risk prostate cancer. This study focused on the evaluation of the dosimetric results and treatment delivery efficiency.

METHODS AND MATERIALS

CT data sets of 21 consecutive high-risk prostate cancer patients who were treated with RapidArc in our institution between September 2011 and May 2012 were included in this study. CT scans were acquired in the supine position, with 1.25-mm slice thickness from upper abdomen to 5 cm below the ischial tuberosities after immobilisation with a vacuum-based device (VacLoc™; Med-Tec, Orange City, IA). The prostate clinical target volume (CTV) was defined as the entire prostate and proximal 1.5 cm of the seminal vesicles and any visible tumour extension. The prostate planning target volume (PTV) was generated by adding an 8-mm margin to the prostate CTV in all dimensions, except posteriorly where a 5-mm margin was used. Pelvic lymph node volumes were standardised based on the consensus recommendations of the Radiation Therapy Oncology Group (RTOG) [14]. The nodal CTV consisted of a 0.7-cm expansion volume on the common, external and internal iliac vessels and the obturator vessels while excluding adjacent bone, muscle, bowel and bladder. The nodal CTV commenced at the L5 to S1 interspace, with the external iliac nodal volumes stopping at the top of the femoral head and the obturator nodal volumes stopping at the top of pubic symphysis. According to our usual practice, but differing from the RTOG consensus, the presacral nodes were not included in the nodal CTV. The nodal PTV was defined by a 0.5-cm expansion of the nodal CTV. Contouring of OARs, including the rectum, bladder, femoral heads and bowel bag, were defined according to the RTOG pelvic normal tissue contouring guidelines [15]. The OARs were contoured and considered as solid organs. The rectum was segmented starting at the level of ischial tuberosities to the rectosigmoid flexure, and the bladder was contoured from its base to the dome. The femoral heads were delineated to the level of the ischial tuberosities. The bowel bag was defined as the entire volume of peritoneal space in which the small bowel can move.

Treatment was prescribed such that the prostate PTV received 70 Gy in 28 fractions (2.5 Gy per fraction), while the nodal PTV

simultaneously received 50.4 Gy (1.8 Gy per fraction). In all cases, dose normalisation was set to mean dose to the prostate PTV while keeping the mean dose to the nodal PTV as close to 50.4 Gy as possible. Plans were considered acceptable if $\geq 95\%$ of the PTVs received $\geq 95\%$ of the prescription dose and the prostate PTV volume receiving $>107\%$ of the prescription dose was limited to 2%. The target volume and critical structure dose constraints are detailed in Table 1. During the optimisation process, the primary goal was to achieve a similar PTV coverage for both the VMAT and the IMRT techniques. The secondary goal was to decrease the OAR doses as much as possible.

Three treatment plans were generated using two-arc RapidArc, 7-f IMRT and 9-f IMRT by an experienced radiation oncologist. All treatment plans were developed in the Eclipse v. 10.0 treatment planning system using 10-MV photons in a Novalis Tx treatment unit (Varian Medical Systems, and BrainLAB AG, Feldkirchen, Germany) equipped with a high-definition multi-leaf collimator (HD-MLC, a spatial resolution of 2.5 mm at isocenter) at a maximum dose rate of 1000 MU min⁻¹. For all techniques, the final dose calculation was performed using the anisotropic analytical algorithm. The RapidArc plans were optimised for two arcs, with Beam 1 rotating from 181° to 179° and Beam 2 rotating from 179° to 181°. The collimator was set to 30° for Beam 1 and 330° for Beam 2. For the RapidArc plans, a dose rate of 600 MU min⁻¹ was set as the upper limit. Figure 1 shows beam's eye views of Beams 1 and 2. Equally spaced 7-f and 9-f dynamic MLC-based IMRT plans were generated. The arrangement of the fields is shown in Figure 2. All IMRT plans used a fixed-dose rate of 300 MU min⁻¹. The initial optimisation parameters for both RapidArc and IMRT are listed in Table 2. These constraints and priorities were set initially and then were modified during the optimisation process based on the real-time updated dose-volume histograms (DVHs) of the structures. In addition, three pseudostructures, Bladder-O (bladder minus PTVs with an extra 4-mm margin), Rectum-O (rectum minus PTVs with an extra 4-mm margin) and Bowel bag-O (bowel bag minus PTVs with an extra 4-mm margin) were generated for

Table 1. Dose-volume constraints used for plan evaluation

Structure	Dose-volume constraints
Prostate PTV	$D_{95\%} \geq 66.5 \text{ Gy}$
	$D_{2\%} \leq 74.9 \text{ Gy}$
Nodal PTV	$D_{95\%} \geq 47.9 \text{ Gy}$
Rectum	$V_{65\text{Gy}} \leq 15\%$
	$V_{45\text{Gy}} \leq 45\%$
Bladder	$V_{65\text{Gy}} \leq 25\%$
	$V_{45\text{Gy}} \leq 50\%$
Femoral heads	$D_{2\%} \leq 50 \text{ Gy}$
Bowel bag	$D_{2\%} \leq 52 \text{ Gy}$
	$D_{\text{max}} \leq 55\text{--}60 \text{ Gy}$

D_{max} , maximum dose to the structure; $D_n\%$, minimal dose to $n\%$ of the structure; PTV, planning target volume; $V_{n\text{Gy}}$, percentage structure volume receiving $\geq n \text{ Gy}$.

Figure 1. An example of beam's eye views at gantry angle 181° for (a) Beam 1 and (b) Beam 2 of the RapidArc® (Varian Medical Systems, Palo Alto, CA) plans. Pink = prostate planning target volume; light green = nodal planning target volume; yellow = rectum; cyan = light femoral head; blue = left femoral head.

optimisation. The optimisation constraints and priorities of these pseudostructures were not initially applied and were real-time adjusted during the progression of optimisation. We generated the RapidArc plan first. Then, we generated IMRT plans to match the PTV coverage of the RapidArc plan. After that, we performed several optimisations for the IMRT plans to achieve dose sparing of the OARs as much as possible while maintaining the target coverage. These efforts were also made for RapidArc planning for a fair comparison in this study. Finally, we compared optimal RapidArc, 7-f IMRT and 9-f IMRT plans.

DVHs for the prostate PTV, nodal PTV, rectum, bladder and bowel bag were calculated for each subject. DVHs were averaged among 21 subjects. Parameters chosen for comparison were $D_{2\%}$, $D_{95\%}$ and $D_{98\%}$ for the prostate PTV and mean dose and $D_{95\%}$ for the nodal PTV, where $D_{n\%}$ is the minimal dose delivered to the percentage of the structure. Conformity index (CI) and homogeneity index (HI) were calculated for the prostate PTV. CI was defined as the volume included in the 95% isodose divided by the volume of the prostate PTV. HI was calculated as $(D_{2\%} - D_{98\%})/D_{50\%}$. For the rectum and bladder, the analysis included the mean dose, $V_{65\text{Gy}}$ and $V_{45\text{Gy}}$, where $V_{n\text{Gy}}$ is the percentage structure volume receiving at least n Gy. $D_{2\%}$ of each femoral head and $D_{2\%}$ and $V_{45\text{Gy}}$ of bowel bag were also compared. The integral dose (ID) for each plan was calculated by multiplying the mean dose and total irradiated body volume (target was excluded). The total number of MUs per fraction and the treatment time were used to evaluate the efficiency of treatment delivery. The treatment time for each plan was recorded by

performing a “dry run” test on the Novalis Tx treatment unit. We added 20 s per field for non-beam-on time, which included the time needed to reconfigure the linear accelerator between one field and the other.

Dose–volume parameters, CI, HI, ID, MU and treatment time for each plan, were compared by the two-sided Wilcoxon matched-pair signed-rank test for non-parametric data with a significance level of $p \leq 0.01$.

RESULTS

The mean volumes of the prostate PTV and nodal PTV for the 21 subjects in this study were 97 cm^3 (range $62\text{--}156 \text{ cm}^3$) and 676 cm^3 (range $557\text{--}808 \text{ cm}^3$), respectively. Figure 3 shows the comparison of dose distributions for a typical subject for each of the three treatment techniques.

All dose–volume constraints were met satisfactorily by all three treatment techniques for all treatment plans. The average DVHs for the prostate PTV, nodal PTV, rectum, bladder and bowel bag are shown in Figure 4. The DVHs for RapidArc and both IMRTs for prostate PTV, nodal PTV and bowel bag were similar to each other. 9-f IMRT provided better sparing of the rectum and bladder when compared with RapidArc and 7-f IMRT, which were similar to each other.

Table 3 shows the mean value of the dosimetric parameters of the three treatment techniques with their respective statistical levels. Although the resulting dosimetric parameters for the prostate

Figure 2. Representative axial CT slices showing the arrangement of fields for (a) 7-field intensity-modulated radiation therapy and (b) 9-field intensity-modulated radiation therapy.

Table 2. Initial optimisation parameters for both RapidArc® and IMRT

Structure	Volume (%)	Dose (Gy)	Priority
Body	0	71.0	150
Prostate PTV	0	71.0	100
	100	68.0	100
Nodal PTV	100	47.5	100
Rectum	0	70.0	80
	15	60.0	80
Bladder	0	70.0	80
	25	60.0	80
Femoral heads	0	50.0	50
Bowel bag	0	50.4	100

PTV, planning target volume.

RapidArc is developed by Varian Medical Systems, Palo Alto, CA.

PTV were almost identical for all approaches, the RapidArc plans resulted in statistically significantly lower $D_{2\%}$, CI and HI. All plans were comparable with respect to the dose to the nodal PTV. For the rectum D_{mean} , $V_{65\text{Gy}}$ and $V_{45\text{Gy}}$ and the bladder $V_{45\text{Gy}}$, the results indicated that the 9-f IMRT plans had significantly lower values than the RapidArc and 7-f IMRT plans. A reduction in $D_{2\%}$ of both the right and left femoral heads was observed with RapidArc. Bowel bag $D_{2\%}$ and $V_{45\text{Gy}}$ did not differ. As for the mean IDs, RapidArc provided better plans than both 7-f IMRT and 9-f IMRT.

The RapidArc plans used significantly fewer mean MUs (526 ± 61 MU) to treat a single fraction than 7-f IMRT (2383 ± 279 MU, $p < 0.001$) and 9-f IMRT (2588 ± 271 MU, $p < 0.001$). The mean treatment times for RapidArc, 7-f IMRT and 9-f IMRT were 171 ± 1 s, 737 ± 58 s and 865 ± 53 s, respectively, showing that the RapidArc plans significantly reduced treatment time than both IMRT plans ($p < 0.001$).

Figure 3. Representative RapidArc® (Varian Medical Systems, Palo Alto, CA), 7-field intensity-modulated radiation therapy (7-f IMRT), and 9-field IMRT (9-f IMRT) dose distribution. Prostate planning target volumes (PTVs) are shown in pink and nodal PTVs are shown in light green.

DISCUSSION

In this study, we compared the quality of the RapidArc technique with that of 7-f IMRT and 9-f IMRT in the treatment of high-risk prostate cancer patients with prophylactic pelvic radiotherapy and simultaneous dose escalation to the prostate. All the three techniques were able to meet all of our plan acceptance criteria. We showed that RapidArc resulted in slightly superior conformity and homogeneity of prostate PTV, but the absolute differences in the dosimetric parameters were very small. The 7-f IMRT and RapidArc plans were similar in regard to rectum and bladder sparing, whereas the 9-f IMRT plan was superior to both RapidArc and 7-f IMRT. Nonetheless, the RapidArc plans were found to provide significantly improved delivery efficiency than both IMRT plans.

In general, two-arc VMAT can achieve higher conformity and homogeneity compared with a one-arc plan. All the RapidArc plans generated in this study used two arcs because one-arc RapidArc was not dosimetrically feasible given the complexity of the dose distribution (data not shown). Generally, better quality IMRT plans can be obtained with a larger number of fields at the expense of higher MUs and longer treatment times. In this study, we decided to use 7-f IMRT and 9-f IMRT, which are the irradiation techniques used in actual clinical practice. We set the IMRT dose rate at 300 MU min^{-1} , which is currently used for patient treatment in our institution. During the optimisation process of each subject, special care was taken to match the PTV coverage among RapidArc plans and the two IMRT plans, with the aim of avoiding a trade-off between PTV coverage and OAR sparing. Multiple plans were generated as we performed optimisation several times, further tightening dose-volume constraints of the OARs each time, and the most preferable plan was selected.

Prostate cancer is one of the most common tumour sites where dosimetric comparison between VMAT and IMRT is performed. Most studies on dosimetric comparison in prostate-only or prostate with seminal vesicles found that one-arc VMAT provided equivalent or superior target coverage and OAR sparing compared with 5-f IMRT or 7-f IMRT [2,3,5,6,8–10,12]. However, there are very little data in the literature on dosimetric comparisons between VMAT and multiple-field IMRT in the treatment of high-risk prostate cancer with whole-pelvic radiotherapy, and the results are somewhat inconsistent. Yoo et al [4] performed a planning study comparing 9-f IMRT with one-arc and two-arc VMAT produced with the RapidArc system for PTVs, including prostate, seminal vesicles and lymph nodes in 10 patients with high-risk prostate cancer and reported that IMRT performed better in organ sparing for bladder, rectum and small bowel than VMAT. Several planning studies conducted dosimetric comparison between VMAT and IMRT using a simultaneous integrated boost strategy in the high-risk prostate setting [7,11,13]. Davidson et al [7] concluded that two-arc VMAT and 7-f IMRT were equivalent in dosimetric quality. However, no statistical analysis was performed. Differing from our results, Fontenot et al [13] showed that one-arc VMAT plans were dosimetrically equivalent to 9-f IMRT plans. One potential reason for differing outcomes between the studies may be the

Figure 4. Average dose-volume histograms (DVHs) for RapidArc® (Varian Medical Systems, Palo Alto, CA), 7-field intensity-modulated radiation therapy (7-f IMRT), and 9-field IMRT (9-f IMRT), for prostate planning target volume (prostate PTV), nodal PTV, rectum, bladder, and bowel bag.

differences in the target volume: the mean volume of the PTV (including prostate, seminal vesicles and lymph nodes) was 350 cm^3 in the study by Fontenot et al [13] compared with 773 cm^3 in the present study. Myrehaug et al [11] performed a planning comparison in 15 patient data sets between two- or three-arc VMAT and 7-f IMRT and found VMAT to have no consistent dosimetric advantage in either the PTV or the OARs when compared with IMRT. Given the results of the present study, the quantitative dosimetric difference could be small in transition from multiple-field IMRT to VMAT for complicated and large PTV including pelvic lymph node. Although our results demonstrated statistically significant differences in OAR sparing among the treatment techniques, the absolute differences in dosimetric

parameters were small; therefore, whether these dosimetric benefits will reflect clinical outcomes remains to be determined.

A major advantage of VMAT over conventional IMRT originates from the superior delivery efficiency, but not the dosimetric performance. In our study, the treatment delivery efficiency was noticeably improved with RapidArc. The reduction in treatment time could reduce the intrafractional pelvic and prostate motion. Moreover, this time saving could be used to increase patient throughput on a treatment unit that provides additional time for online image guidance without increasing the overall treatment time. Meanwhile, the decrease in MUs required with VMAT reduces whole-body exposure of the patient owing to

Table 3. Dosimetric comparisons of RapidArc, 7-f IMRT and 9-f IMRT

Parameter		Treatment techniques			Wilcoxon matched-pair signed rank <i>p</i>		
		RapidArc (mean±SD)	7-f IMRT (mean±SD)	9-f IMRT (mean±SD)	RapidArc vs 7-f IMRT	RapidArc vs 9-f IMRT	7-f IMRT vs 9-f IMRT
Prostate PTV	$D_{2\%}$ (Gy)	71.20±0.20	71.70±0.20	71.70±0.30	<0.001 ^a	<0.001 ^a	0.920
	$D_{95\%}$ (Gy)	68.50±0.20	68.40±0.30	68.40±0.20	0.330	0.470	0.970
	$D_{98\%}$ (Gy)	67.90±0.30	67.90±0.40	67.90±0.30	0.470	0.071	0.860
	CI	1.23±0.04	1.30±0.06	1.29±0.04	<0.001 ^a	<0.001 ^a	0.012
	HI	0.05±0.01	0.05±0.01	0.05±0.01	<0.001 ^a	<0.001 ^a	0.680
Nodal PTV	D_{mean} (Gy)	50.90±0.40	50.90±0.50	51.00±0.40	0.650	0.082	0.008 ^a
	$D_{95\%}$ (Gy)	48.40±0.40	48.50±0.40	48.70±0.30	0.250	0.010	0.010
Rectum	D_{mean} (Gy)	37.50±3.00	37.10±3.00	34.80±2.70	0.082	<0.001 ^a	<0.001 ^a
	$V_{65\text{Gy}}$ (%)	10.30±2.40	10.40±2.20	9.40±2.10	0.730	0.004 ^a	<0.001 ^a
	$V_{45\text{Gy}}$ (%)	31.10±5.10	30.00±4.60	25.50±4.40	0.016	<0.001 ^a	<0.001 ^a
Bladder	D_{mean} (%)	43.10±2.09	43.20±3.10	42.00±3.30	0.730	0.016	<0.001 ^a
	$V_{65\text{Gy}}$ (%)	14.50±5.20	14.80±5.30	14.30±5.20	0.048	0.440	0.012
	$V_{45\text{Gy}}$ (%)	42.90±7.20	43.20±7.60	39.80±7.70	0.250	<0.001 ^a	<0.001 ^a
Left femoral head	$D_{2\%}$ (Gy)	41.30±2.90	44.90±1.60	44.00±1.30	<0.001 ^a	<0.001 ^a	0.001 ^a
Right femoral head	$D_{2\%}$ (Gy)	41.20±4.20	44.10±1.70	43.20±2.00	0.002 ^a	0.006 ^a	0.005 ^a
Bowel bag	$D_{2\%}$ (Gy)	49.00±2.20	49.60±1.60	49.60±2.10	0.220	0.056	0.380
	$V_{45\text{Gy}}$ (cm ³)	170±47	174±41	169±43	0.110	0.810	0.024
Integral dose	(Gy l)	220±27	236±27	235±27	<0.001 ^a	<0.001 ^a	0.340

7-f IMRT, 7-field intensity-modulated radiation therapy; 9-f IMRT, 9-field IMRT; CI, conformity index; D_{mean} , mean dose to the structure; $D_{n\%}$, minimal dose to *n*% of the structure; HI, homogeneity index; PTV, planning target volume; SD, standard deviation; $V_{n\text{Gy}}$, percentage structure volume receiving $\geq n$ Gy.

Two-sided *p*-values calculated using Wilcoxon matched-pair signed rank test.

^aSignificant at $p \leq 0.01$.

leakage radiation, which is a concern regarding the development of secondary malignancies [16]. The ID was statistically significantly lower for RapidArc than for both 7-f IMRT and 9-f IMRT in our study. Yoo et al [4] and Myrehaug et al [11] have reported a higher ID with VMAT than with IMRT, whereas Ost et al [17] reported no difference in ID between VMAT and IMRT. Thus, the results on ID are varied between the studies. A possible reason for this is that ID is related not only to MUs but also to

aperture sizes and shapes and target volumes and shapes [4]. Myrehaug et al [11] reported that VMAT was associated with a significantly decreased treatment time (6.3 min vs 7.7 min) and median number of MUs per plan (724 MU vs 1075 MU) in comparison with IMRT for hypofractionated prostate cancer radiotherapy with whole-pelvic nodal irradiation. However, the absolute difference in treatment time was smaller than what we typically expect with VMAT technology as well as that seen in

our study. One possible explanation is variation in the radiation treatment system: our study used the Varian RapidArc system and compared with dynamic MLC-based IMRT, whereas the study by Myerhaug et al [11] used the Elekta (Stockholm, Sweden) VMAT platform and compared with segmented MLC-based IMRT. Furthermore, we performed IMRT planning on an Eclipse treatment planning system using Novalis Tx, which has a limitation that MLC cannot travel beyond 15 cm. To overcome this limit, a large IMRT beam is automatically split into two or three subfields, causing increased treatment time. In this study, all beams of the IMRT plans were split into two subfields. Therefore, the levels of treatment efficiency obtained with VMAT could differ depending on the system used and the IMRT techniques compared.

CONCLUSIONS

We have demonstrated that RapidArc provided similar OAR sparing to 7-f IMRT, and treatment delivery efficiency is significantly higher for RapidArc than for IMRT. However, 9-f IMRT performed better in rectum and bladder sparing than RapidArc. Although statistically significant differences in OAR sparing were demonstrated among the planning types, the absolute differences in dose were small; thus, the clinical significance is unclear. Considering the superior delivery efficiency and acceptable plan quality, we believe that RapidArc is a reasonable option for the treatment of prostate cancer with hypofractionated simultaneous integrated boost to the prostate when the lymph nodes are involved.

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