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Time Feasibility of Upfront "Brachy-like" SBRT using Adapt-to-Shape Workflow with 1.5T MR-LINAC for Cervical Cancer Definitive Radiotherapy

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ABSTRACT

Purpose: To evaluate the feasibility and adapt-to-shape (ATS) workflow efficiency of a novel, "Brachy-like" Stereotactic Body Radiation Therapy (SBRT) technique delivered via MR-LINAC. This upfront boost aims to deliver a steep-gradient high dose to a "Virtual-Tandem Core PTV" (VTC-PTV) and a moderate dose to the HR-CTV to promote immunopotentiation and tumor reduction prior to conventional chemoradiotherapy and brachytherapy.

Methods: Five treatment-naïve patients with intact-uterus cervical cancers previously treated on a 1.5T MR-LINAC (Elekta Unity) were retrospectively analyzed to maintain clinical relevance to the intended "UPFRONT" workflow. An "UPFRONT" scheme was replanned on the original planning CT. A 2-cm diameter VTC-PTV was generated along the central HR-CTV core using an automated central spline function. A single-fraction simultaneous integrated boost was prescribed: 8Gy to the VTC-PTV and 3Gy to the HR-CTV. IMRT plans (12-beam template) were optimized to meet stringent OAR constraints: Bladder D2cc <3Gy and Rectum/Sigmoid D2cc <2.2Gy. ATS workflow was implemented offline, with two medical physicists and two radiation oncologists on the treatment planning console. Workflow metrics, including registration, contouring, and optimization times, were recorded. Dosimetric consistency between the initial planning CT and post-adaptive plans was evaluated.

Results: The median (range) adaptive workflow times were: total time 7.8 (5.4–10.9) min; registration 1.1 (0.5–3.1) min; contouring 4.3 (2.2–6.4) min; and optimization 1.5 (1.3–3.3) min. The median estimated delivery time was 10.3 (9.6–12.6) min. No statistically significant dosimetric differences were observed between planning CT and post-adaptive plans with pre-/post- adaptive dose for VTC-PTV Dmax 11.8(10.1-12.9)/ 11.1(10.9-12.7) Gy, D90% 8.2(6.2-8.9)/ 7.8(6.3-8.8) Gy; HR-CTV D90%3.2(3.1-3.4)/3.2(3.0-3.5)Gy; D2cc Bladder 2.7(2.5-2.7)/2.7(2.6-2.7)Gy, Rectum 1.8(1.5-1.9)/1.7(1.4-1.8) Gy, and Sigmoid 1.7 (0.7-2)/1.6(0.5-1.9) Gy.

Conclusion: Upfront MR-guided "Brachy-like" SBRT for cervical cancer is clinically feasible within a highly efficient time frame. The workflow is particularly optimized in treatment-naïve patients, supporting its role as a potential induction therapy.

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INTRODUCTION

"Brachy-like" Stereotactic Body Radiation Therapy (SBRT) technique delivered via MR-LINAC as upfront boost is aimed to deliver a steep-gradient high dose to a "Virtual-Tandem Core PTV" (VTC-PTV) and a moderate dose to the HR-CTV to promote immunopotentiation and tumor reduction prior to conventional chemoradiotherapy and brachy.

This study is to evaluate the feasibility and adapt-to-shape (ATS) workflow efficiency

METHODS AND MATERIALS

Five treatment-naïve patients with intact-uterus cervical cancers previously treated on a 1.5T MR-LINAC (Elekta Unity) were retrospectively analyzed to maintain clinical relevance to the intended **"UPFRONT Brachy-like"** workflow.

ATS workflow was implemented offline, with two medical physicists and two radiation oncologists on the treatment planning console. Workflow metrics, including registration, contouring, and optimization times, were recorded. Dosimetric consistency between the initial planning CT and post-adaptive plans was evaluated.

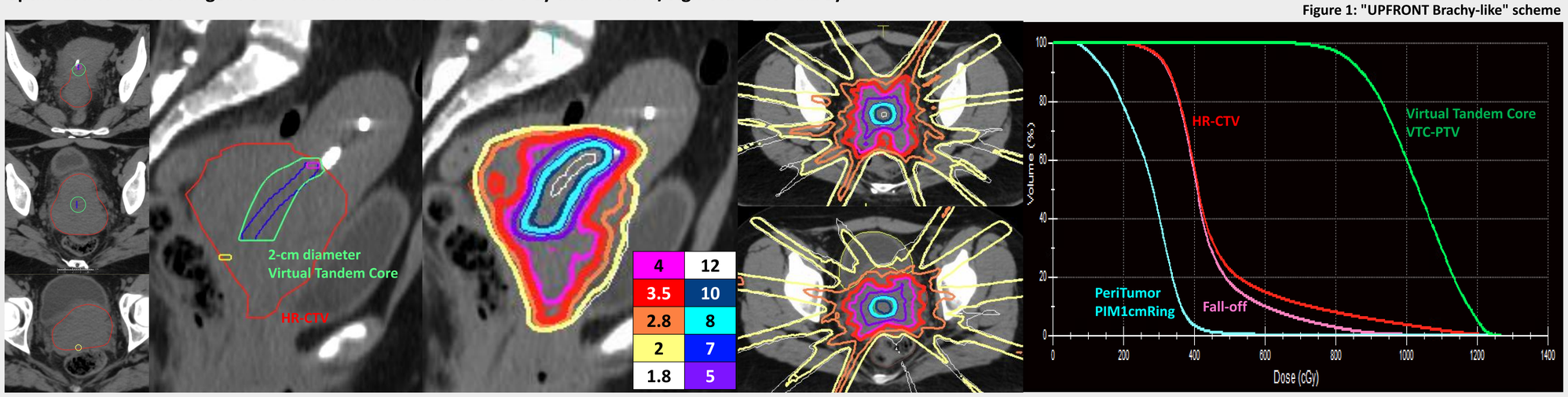
DISCUSSION

ATS workflow is clinically feasible within highly efficient time frame:
Adaptive Planning <10 min and Delivery <15 min.
No statistically significant dosimetric differences were observed between planning CT and post-adaptive plans.

Important learning point:
***Initial Treatment Naïve Tumor is much easier to do adapt-to-position (ATP) with minimal OAR ATS Compared to the more mobile Post EBRT tumor**

An "UPFRONT Brachy-like" scheme (Figure 1) was replanned on the original planning CT. A 2-cm diameter VTC-PTV was generated along the central HR-CTV core using an automated central spline function. A single-fraction simultaneous integrated boost was prescribed: 8Gy to the VTC-PTV and 3Gy to the HR-CTV. IMRT plans (12-beam template) were optimized to meet stringent OAR constraints: Bladder D2cc <3Gy and Rectum/Sigmoid D2cc <2.2Gy.

Figure 1: "UPFRONT Brachy-like" scheme



RESULTS

Time utilization and pre/post dose evaluation in adaptive planning workflow demonstrated favorable range for practical implementation as shown in **Figures 2-3 and Table 1.**

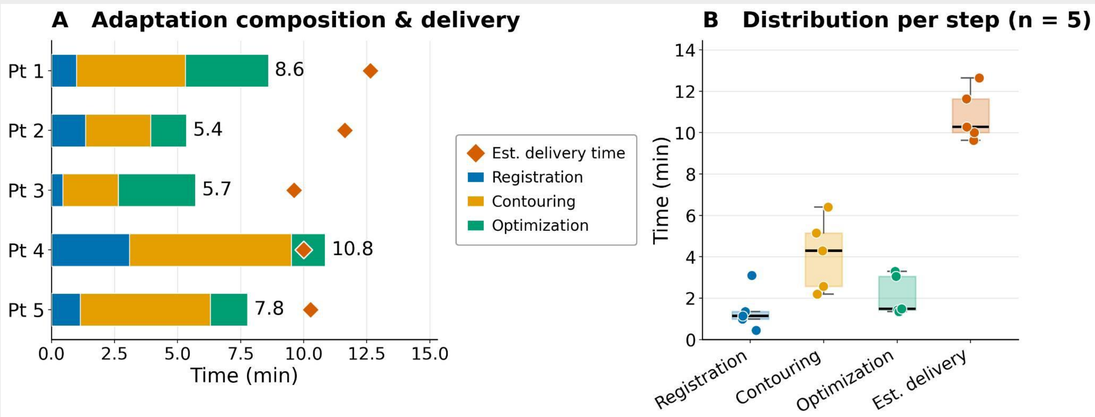


Figure 2: Adaptive workflow time

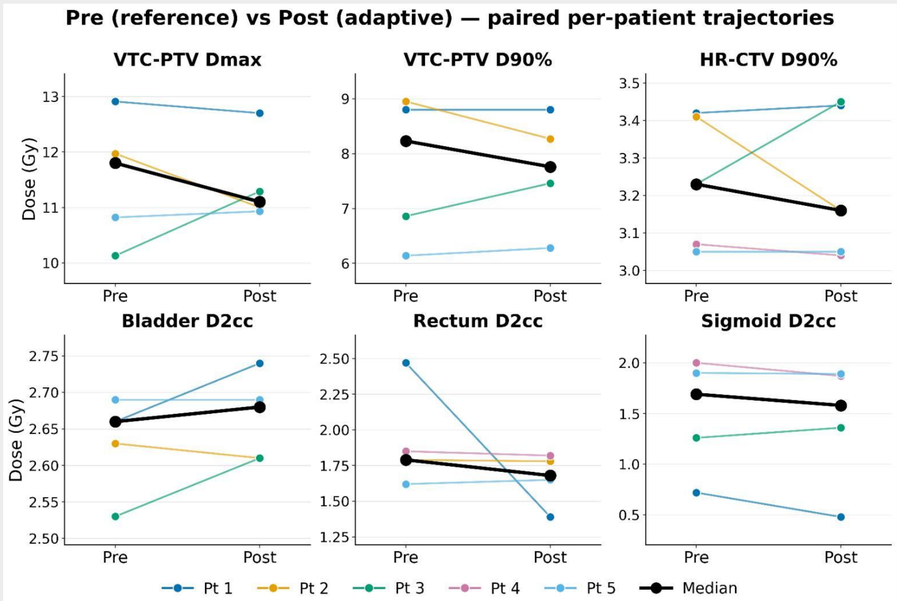


Figure 3: Paired Pre (Reference) VS Post (Adaptive) dose in each patient (Bold-line = median)

Table 1: Individual patient data

Patient	Adaptive planning (min)				Estimated delivery time (min)	Pre/Post adaptive dose (Gy)											
	Registration	Contouring	Optimization	Total		VTC-PTV Dmax		VTC-PTV D90%		HR-CTV D90%		Bladder D2cc		Rectum D2cc		Sigmoid D2cc	
						Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
1	1.00	4.30	3.30	8.60	12.64	12.91	12.70	8.80	8.80	3.42	3.44	2.66	2.74	2.47	1.39	0.72	0.48
2	1.35	2.58	1.43	5.36	11.63	11.97	11.00	8.95	8.27	3.41	3.16	2.63	2.61	1.79	1.78	1.69	1.58
3	0.45	2.20	3.06	5.71	9.62	10.13	11.29	6.86	7.46	3.23	3.45	2.53	2.61	1.79	1.68	1.26	1.36
4	3.10	6.40	1.35	10.85	10.00	11.80	11.10	8.23	7.76	3.07	3.04	2.66	2.68	1.85	1.82	2.00	1.87
5	1.14	5.15	1.49	7.78	10.27	10.82	10.93	6.14	6.28	3.05	3.05	2.69	2.69	1.62	1.65	1.90	1.89
Median	**1.14**	**4.30**	**1.49**	**7.78**	**10.27**	**11.8**	**11.1**	**8.23**	**7.76**	**3.23**	**3.16**	**2.66**	**2.68**	**1.79**	**1.68**	**1.69**	**1.58**

CONCLUSIONS

Upfront MR-guided "Brachy-like" SBRT for cervical cancer is clinically feasible within a highly efficient time frame.
The workflow is particularly optimized in treatment-naïve patients, supporting its role as a potential induction therapy.

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