Practical clinical application of stereotactic MR-guided adaptive radiotherapy boost for cervical cancer patients unable to receive brachytherapy

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Background

- In locally advanced cervical cancer, a brachytherapy boost is an essential part of curative chemoradiation
- Where a brachytherapy boost is not feasible, survival is poor
- Stereotactic MR-guided adaptive radiotherapy (SMART) boost offers a potentially efficacious alternative

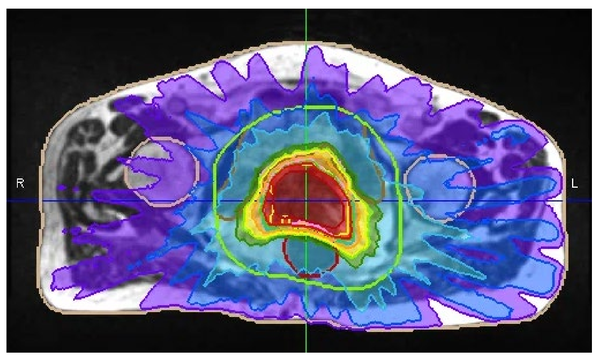

Figure 1: Representative example of a SMART boost treatment plan

Objectives

- To present the following treatment delivery parameters for patients treated with SMART boost for cervical cancer at our institution: biologically equivalent radiotherapy dose (α/β = 10 tumour; 5 bladder/rectum; 4 bowel), overall treatment time (OTT), in-room treatment time, and clinical outcomes.

Methods

- Three cases were treated with SMART boost following standard of case phase 1 external beam radiotherapy of 45 Gy in 25#
- The prescribed dose to the PTV was 30 Gy in 5#, with a simultaneous integrated boost of 35 Gy to the CTV, using a 3 mm planning target volume (PTV) margin
- Target EQD2 dose metrics were: PTVhigh D90% ≥ 85 Gy, PTV D90% ≥ 80 Gy, CTV D90% ≥ 90 Gy, PTV D2% < 52.5 Gy, bladder D2cc < 90 Gy, and bowel/rectum D2cc < 75 Gy
- Delivered doses and treatment parameters were recorded at each fraction and accumulated across the treatment course
- OTT was defined as the number of days between initiation of phase 1 external beam radiotherapy and completion of the phase 2 MR-Linac boost
- The target OTT was ≤ 56 days, with 70 days considered the maximum acceptable duration
- OTT is distinct from treatment delivery time, defined as the per-fraction on-couch treatment duration

Results

- All patients completed treatment, as shown in Table 1
- One fraction was rescheduled due to patient pain/nausea
- OTT was 62,69, and 77 days, respectively

Table 1: Summary of three cases

Age	Diagnosis	Eligibility	OTT	Reason for delay	Toxicity	12-week scan
67	4A G2 SCC	Failed BT – anatomy	62	#1 pain/nausea	Nil	CR, fistula
74	3B G3 SCC	Failed BT – movement	69	Patient contact	Nil	CR
53	3C1 SCC	Failed BT – anatomy	77	Transport/travel	Nil	CR

- Mean in-room treatment time was 63 minutes (range: 42–109)
- All patients achieved complete response at 12 weeks
- Across all cases, daily adapted plans maintained key target dose metrics; PTVhigh D90% was 98–103% of the planned dose, with PTV D2% similarly consistent
- This shows that the peak doses and coverage of the PTV excluding overlap with OARs remained high
- Case 1 (bladder empty due to fistula) demonstrated the largest reduction in tumour coverage due to bowel proximity, with CTV and PTV D90% reduced to 82–84% of planned values, while PTVhigh was maintained at 102.6% (83.3 Gy)
- Mandatory OAR dose constraints were achieved in all cases except for bowel constraints in Case 1, as indicated in Table 2

Table 2: Planned and delivered doses with percentage difference and total EQD2

	Metric	Planned	EQD2 Planned	EQD2 Delivered	% difference	Total EQD2
Patient 1						
CTV-HR	D(90%)	31.7 Gy	43.2 Gy	36.1 Gy	83.5%	80.3 Gy
PTV-HR	D(90%)	25.2 Gy	31.6 Gy	25.9 Gy	82.0%	70.2 Gy
	D(2%)	52.0 Gy	88.4 Gy	87.1 Gy	98.5%	131.33 Gy
PTVHigh	D(90%)	28.9 Gy	38.0 Gy	39.0 Gy	102.6%	83.3 Gy
Bladder	D(2 cc)	29.5 Gy	45.9 Gy	41.7 Gy	90.9%	85.5 Gy
Rectum	D(2 cc)	22.5 Gy	30.5 Gy	26.8 Gy	87.7%	70.5 Gy
Bowel	D(2 cc)	21.5 Gy	29.7 Gy	32.8 Gy	110.2%	76.3 Gy
Patient 2						
CTV-HR	D(90%)	31.8 Gy	43.4 Gy	44.9 Gy	103.5%	89.2 Gy
PTV-HR	D(90%)	24.2 Gy	29.9 Gy	32.0 Gy	106.9%	76.3 Gy
	D(2%)	52.2 Gy	88.9 Gy	89.2 Gy	100.3%	133.5 Gy
PTVHigh	D(90%)	31.4 Gy	42.1 Gy	42.4 Gy	100.6%	86.6 Gy
Bladder	D(2 cc)	23.1 Gy	31.8 Gy	33. Gy	106.2%	77.4 Gy
Rectum	D(2 cc)	22.2 Gy	29.9 Gy	28.9 Gy	96.7%	72.7 Gy
Bowel	D(2 cc)	19.3 Gy	25.3 Gy	26.2 Gy	103.6%	69.7 Gy
Patient 3						
CTV-HR	D(90%)	37.1 Gy	53.9 Gy	49.9 Gy	88.9%	92.1 Gy
PTV-HR	D(90%)	31.7 Gy	43.2 Gy	38.3 Gy	88.7%	82.5 Gy
	D(2%)	43.8 Gy	68.5 Gy	81.2 Gy	118.6%	125.4 Gy
PTVHigh	D(90%)	31.7 Gy	43.2 Gy	44.5 Gy	103.2%	88.8 Gy
Bladder	D(2 cc)	27.0 Gy	40.1 Gy	38.3 Gy	95.6%	82.1 Gy
Rectum	D(2 cc)	17.9 Gy	21.9 Gy	24.9 Gy	113.3%	68.6 Gy
Bowel	D(2 cc)	11.8 Gy	12.5 Gy	12.7 Gy	101.6%	56.2 Gy

Conclusion

- SMART boost for cervical cancer is feasible and deliverable with favourable clinical outcomes
- Tumour coverage exceeds what is typically achieved with external beam boosts, while peak dose and PTVhigh coverage are consistently maintained

Abbreviations

3B / 3C1 / 4A – FIGO stage classification; **CR** – complete response; **CTV** – clinical target volume; **D2%** – dose received by 2% of the target volume; **D2cc** – dose received by the most irradiated contiguous volume of 2cc; **D90%** – dose received by 90% of the target volume; **EQD2** – equivalent dose in 2 Gy fractions; **G2 / G3** – histological tumour grade (moderately and poorly differentiated, respectively); **OAR** – organ at risk; **PTVhigh** – high-dose planning target volume; **SCC** – squamous cell carcinoma.

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