

'Plan of the Day' for Cervical Cancer External Beam Radiotherapy

A Dosimetric Evaluation of Bespoke Planning Target Volume Margins

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- EBRT is an integral part of the treatment management of locally advanced cervical cancer.

Main Challenge

Daily anatomical variation
(e.g. bladder and rectal filling)

Uterus/cervix (CTVp) motion
inter- and intra-fraction

Large CTV–PTV margins
avoid geographical misses

Current Local Practice

Pre-treatment:

Full + empty bladder planning CTs

Planning:

CTVp contoured on both scans → ITV created →
PTV margin applied → VMAT planning

Treatment:

Daily CBCT

The Problem

► Risks of large CTV-PTV margins:

- ↓ Normal tissue sparing
- ↑ Risk of toxicities
- **Greater impact in patients with large uterine motion**



Strategies to minimise such risks are warranted – **Adaptive strategies!**

What is 'Plan of the Day' (PoD)?

- ▶ Adaptive RT approach
- ▶ Multiple treatment plans created to account for different target positions/motion.
- ▶ Daily plan selection based on IGRT and clinical decision making.

- ▶ **Aim:**

- ▶ ↓ PTV volume
- ▶ maintain target coverage
- ▶ ↑ OAR sparing
- ▶ ↓ toxicities.

- ▶ **National Drivers:**

- ▶ **RCR consensus statements:**

- ▶ Adoption of PoD or an alternative ART approach - strongly supported

- ▶ **IR(ME)R17**

- ▶ dose optimisation

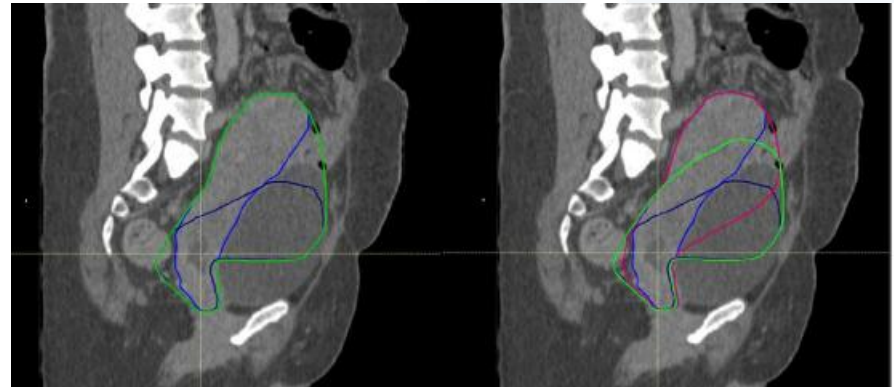


Image from Wang et al. (2023)

*Can PoD reduce PTV volume
and dose to the OAR
compared to current local practice?*

- ▶ Stage 1 of a Service Evaluation – Single institution
- ▶ Retrospective data: 25 patients, 160 CBCTs (semi-random selection of CBCTs: 1 per week + discrepancies)

▶ Phase 1 – Develop the PoD approach:



▶ Phase 2 – Pilot Dosimetric Evaluation

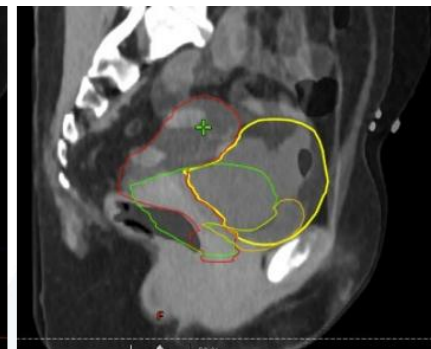
Representative Mover + Non-Mover → PoD plans → OAR dose comparison

Categorisation of Patients

‘Tip-of-uterus’ motion between full and empty bladder scans

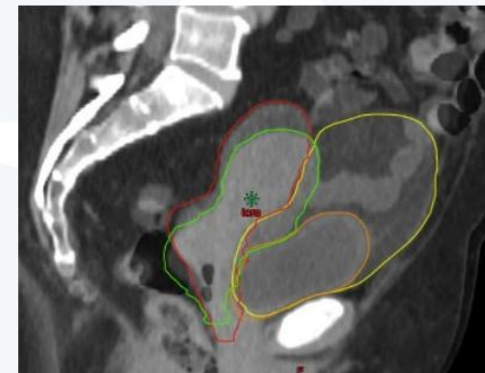
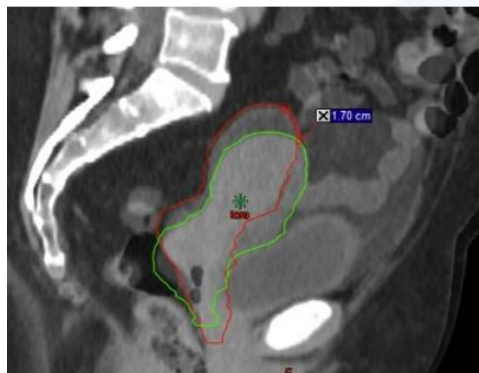
Movers (M)

($\geq 2.5\text{cm}$)

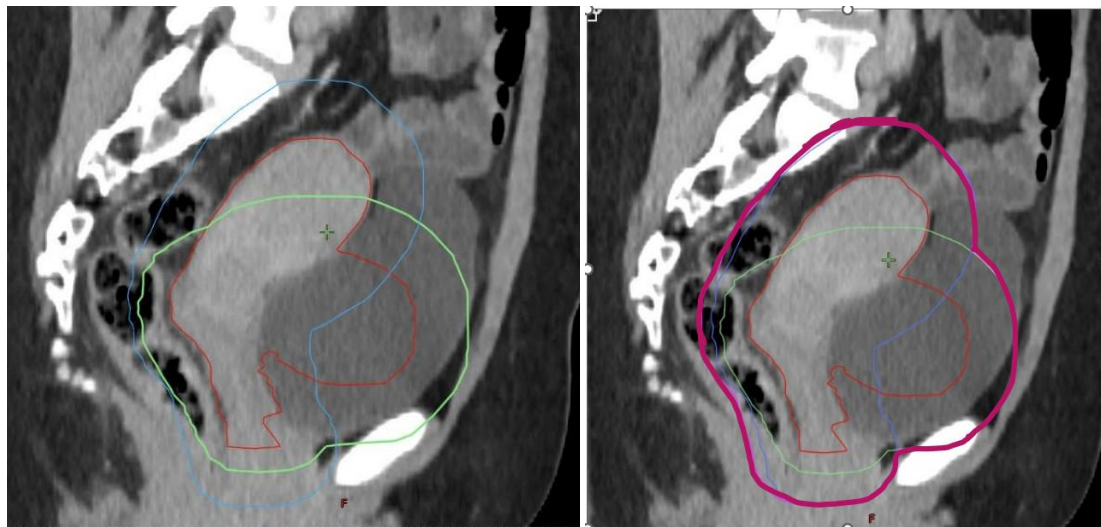


Non-Movers (NM)

(<2.5cm)



The Proposed PoD approach



Library of Plans

FB-plan (Blue): from CTVp on Full Bladder Scan

EB-plan (Green): from CTVp on Full Bladder Scan

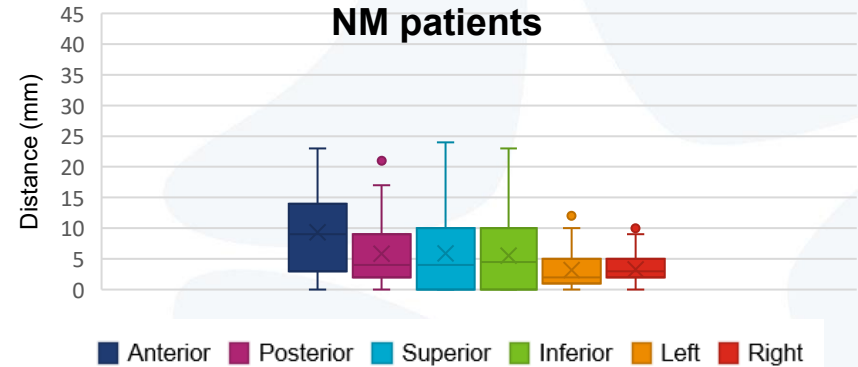
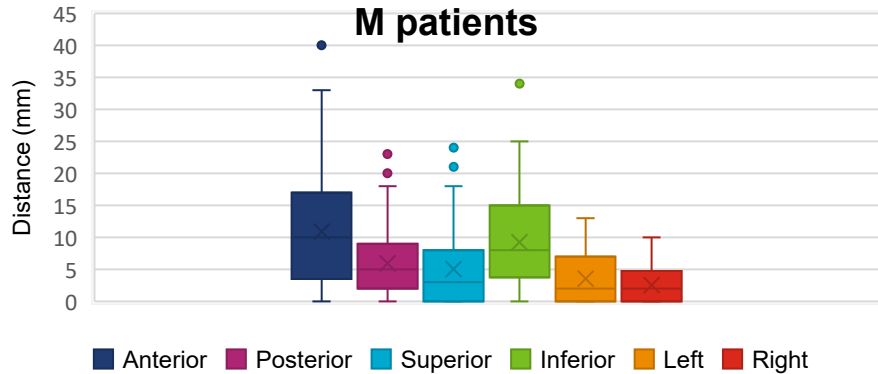
Robust Plan (Magenta): from full ITV

Why this approach?

- Library of 2–3 plans most commonly reported in the literature
- Intermediate uterus positions safely encompassed in the proposed margins
 - No 3rd CT scan or prediction tools are currently available ‘in-house’.
- ‘Robust’ plan = back up plan

Results – CTVp motion

- ▶ Greatest motion observed: anterior/inferior directions (mostly due to bladder filling)
- ▶ Greater variability in Movers
- ▶ 56% of patients were Movers
- ▶ 6/11 Non-Movers had ≤ 1 cm uterine motion



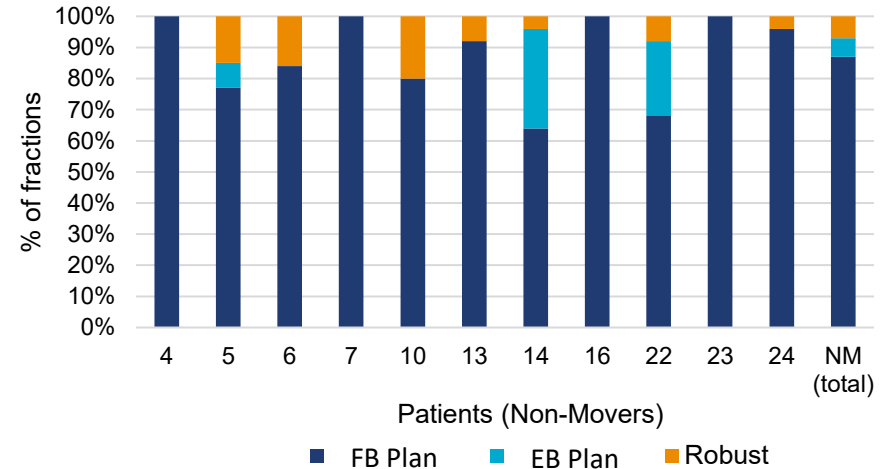
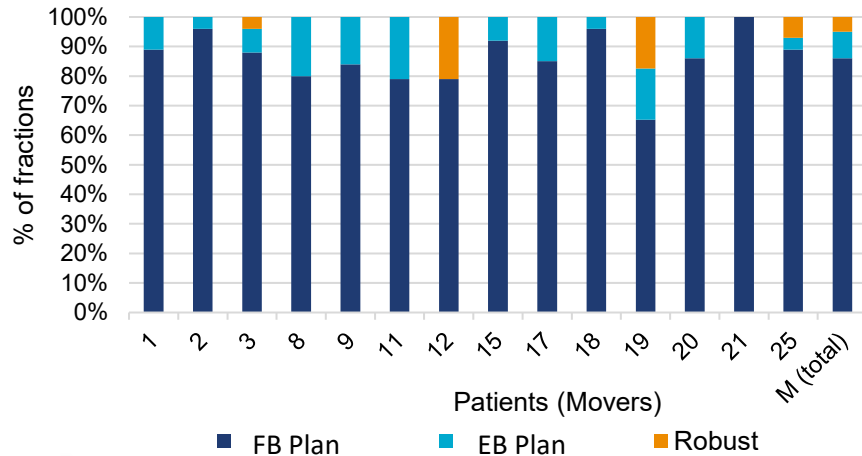
Results – Bespoke PoD margins

- ▶ Bespoke margins derived from **CTVp motion measurements on CBCTs**
 - ▶ Several margins tested using percentile analysis (Zeng et al., 2024)
 - ▶ Selected margins aimed to provide FB-plan coverage for >70% of fractions (Reijtenbagh et al., 2024)

		Anterior	Posterior	Superior	Inferior	Left	Right
Standard Practice/ Robust 'Back up'		20	20	20	20	10	10
PoD:	M	20	15	20	20	10	10
FB-Plan & EB-Plan	NM	18	15	15	18	10	10

Results – Plan Selection

- ▶ Hypothetical PoD PTVs with new margins generated for each patient.
- ▶ Plan selection assessed on all CBCTs (M: 367, NM: 301)
- ▶ **FB plan selected in >80% of fractions** (M: 86%, NM: 87%)
- ▶ **Robust plan rarely used** (M: 5% NM: 8%) – chosen if: OAR filling variation, poor CBCT image quality, tight CTVp coverage



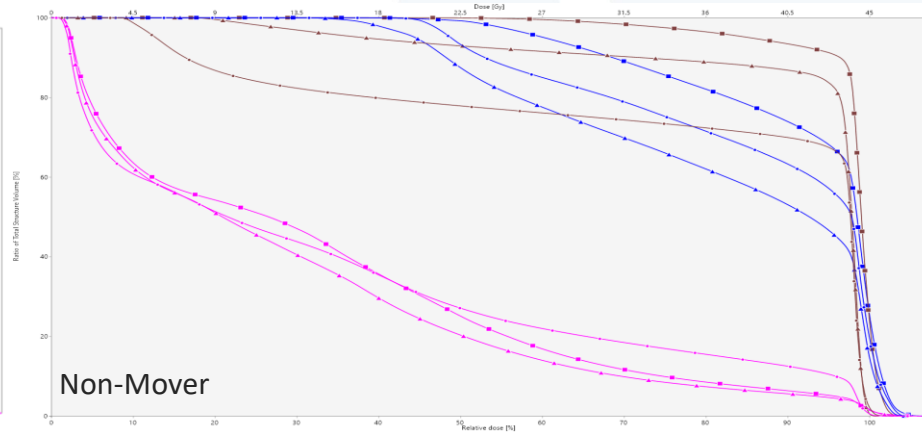
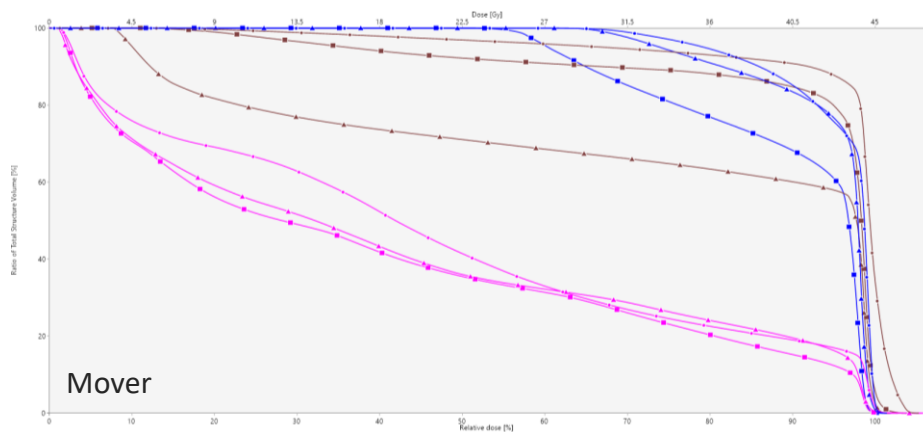
Results – Impact on PTV volume

- ▶ **Significant PTV volume reduction with PoD** ($p < 0.001$)
- ▶ **Movers:** median reduction **14.3%** (range: 9.1–36.8%)
- ▶ **Non-Movers:** median reduction **15.0%** (range: 1.1–23.0%)

		Median	Mean	SD	Minimum	Maximum	p-value
M patients	PTV PoD / PTV Standard	0.86	0.84	0.07	0.63	0.91	<0.001
	% reduction	14.3	15.6	7.0	9.1	36.8	
		Median	Mean	SD	Minimum	Maximum	p-value
NM patients	PTV PoD / PTV Standard	0.85	0.84	0.06	0.77	0.99	<0.001
	% reduction	15.04	15.61	6.44	1.10	22.98	

Results – Pilot Dosimetric Evaluation

- PoD reduced V45Gy for all OAR
- Improved overall normal tissue sparing
- Target coverage maintained in all PoD plans (D98% >42.75 Gy).



Rectum -Brown | Bowel bag – Magenta | Bladder - Blue

■ Clinical/Robust | ▲ FB-to-MB | ● MB-to-EB

Implementation Considerations:

- ▶ **Is PoD needed for everyone?**
 - ▶ Stronger rationale for Movers - greater motion and variability.
 - ▶ Balance clinical benefit vs resource implications – consider a phased implementation?
- ▶ **Resource implications:**
 - ▶ Increased planning workload
 - ▶ Training: plan selection, clinical decision making
- ▶ **Prospective audit:** validate margins, monitor use of back-up plan (robustness of technique)

Study Limitations

- ▶ **Single-centre, retrospective** evaluation
- ▶ CTVp motion assessed on a **subset of CBCTs**
- ▶ **Intra-observer variability:** contouring and measurements
- ▶ Pilot dosimetry limited to **2 representative patients**
- ▶ **Intra-fraction motion** not assessed – expected to be small (Ríos et al., 2018)

Conclusion

- ▶ PoD – ‘bridge’ **between offline and automated online ART.**
- ▶ Proposed approach achieved **smaller PTVs while maintaining target coverage**
- ▶ Pilot dosimetry demonstrated **improved normal-tissue sparing**
 - ▶ This may translate into **reduced treatment-related toxicity**
- ▶ **Recommendation:**
 - ▶ Initial clinical implementation for Movers
 - prospectively evaluate
 - consider wider implementation (clinical benefit vs feasibility vs resource implications)

Thank you!

Questions?

Acknowledgments:

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