Rapid delivery of prostate and nodes (PACE-NODES) treatments at JCUH

PACE-NODES – an exacting trial

The PACE-NODES (PN) trial, opened in late 2022, aims to determine the feasibility of hypofractionated radiotherapy to pelvic nodes along with the prostate and seminal vesicles [1]: **5 fractions** in total for each patient. With three target dose levels and restrictive criteria regarding doses to organs at risk and targets, achieving target and OAR constraints is non-trivial (see figure 1). In addition to dosimetric criteria, the trial also requires completion of delivery within **3 minutes*** to reduce uncertainty associated with intrafraction motion of the target and OARS [2].

*If delivery cannot be completed in under 3 minutes, the trial allows for intrafraction monitoring (Clarity ultrasound used at JCUH) or re-imaging mid-way through treatment.

CTVpsv_4000	At least 95.00 % volume at 40.00 Gy dose
PTVpsv_3625	At least 34.40 Gy dose at 98.00 % volume
PTVpsv_3625	At least 95.00 % volume at 36.25 Gy dose
PTVsv_3000-PTVpsv_3625	At least 95.00 % volume at 30.00 Gy dose
out_PTVn	At least 23.75 Gy dose at 98.00 % volume
out_PTVn	At least 24.50 Gy dose at 50.00 % volume
out_PTVn	At most 25.50 Gy dose at 50.00 % volume
out_PTVn	At most 26.75 Gy dose at 2.00 % volume
Rectum	At most 1.00 cm ³ volume at 36.00 Gy dose
Rectum	At most 2.00 cm ³ volume at 36.00 Gy dose
Rectum	At most 20.00 % volume at 29.00 Gy dose
Rectum	At most 50.00 % volume at 18.10 Gy dose
Bladder	At most 5.00 cm ³ volume at 37.00 Gy dose
Bladder	At most 10.00 cm ³ volume at 37.00 Gy dose
Bladder	At most 40.00 % volume at 18.10 Gy dose
Bowel	At most 1.00 cm ³ volume at 30.00 Gy dose
Bowel	At most 10.00 cm ³ volume at 25.00 Gy dose
Bowel	At most 20.00 cm ³ volume at 25.00 Gy dose
Bowel	At most 100.00 cm ² volume at 18.10 Gy do
Bowel	At most 150.00 cm ³ volume at 18.10 Gy do
FemurHead_L	At most 5.00 % volume at 14.50 Gy dose
FemurHead_R	At most 5.00 % volume at 14.50 Gy dose
PenileBulb	At most 50.00 % volume at 29.50 Gy dose

Challenging to keep organ at risk doses in tolerance while maintaining coverage and homogeneity in nodal PTV



Figure I <u>Trial planning criteria and example dose distribution</u>



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Delivery time

Total beam-on time is not typically optimised for pelvic radiotherapy. PACE-NODES' requirement of delivery within 3 minutes is a unique opportunity to aim for fast, highly conformal treatment.

RayStation offers a single-arc solution to complex rotational delivery. We have recently commissioned a 6MV FFF beam model in RayStation and have replanned previously treated PACE-NODES patients with the new beam and RayStation's "max delivery time" tool to optimise for speed (figure 2). Dose calculation is Monte Carlo, dose to medium.

Methods and results

6 patients were replanned with the quick delivery technique: I of whom had an artificial hip (patient AH). All planning constraints were met for all patients except AH whose nodal volume had slightly lower dose than required by PACE-NODES. Target dose conformality (conformity indices) were unchanged. Plan timings were measured using a stopwatch. Delivery times of the treated clinical plans (flattened beam, max del time not used) ranged from 4.0 to 4.3 minutes. Using only the FFF beam, plan times were largely unchanged. Using only the max del time function, times were also unchanged. With the quicker delivery technique (FFF + max del time), delivery times (excluding AH) ranged from 3.2 to 3.6 mins (see table 1).

Conclusions

Plan delivery times can be improved by using a combination of FFF beams and the "max del time" feature in RayStation. We have shown it is possible to nearly achieve the requirements of PACE-NODES plan delivery speeds without compromising on plan quality.

Max del. time [sec]	ax del. time c]	
400.00		180.00



Figure 2 Using max delivery time tends to make the beam more evenly distributed over all gantry angles (orange diagrams)

Patient	MU	Measured time (min)	Mean dose rate (MU/min)
1	4605	3.6	1297
2 (AH)	5 39	4.8	1078
3	440 I	3.2	1375
4	4523	3.3	1378
5	5164	3.6	1448
6	4379	3.2	1361

 Table I

 Speed-optimised FFF beam plan delivery times

References

[1] - Tree, A.C., Ostler, P., van der Voet, H., Chu, W., Loblaw, A., Ford, D., Tolan, S., Jain, S., Martin, A., Staffurth, J. and Armstrong, J., 2022. Intensity-modulated radiotherapy versus stereotactic body radiotherapy for prostate cancer (PACE-B): 2-year toxicity results from an open-label, randomised, phase 3, non-inferiority trial. *The Lancet Oncology*, *23*(10), pp.1308-1320.

[2] - PACE NODES guidelines: A phase III randomised trial of 5 fraction prostate SBRT versus 5 fraction prostate and pelvic nodal SBRT, version 1.1, published 15/7/2022. ICR-CTSU

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- **Aim**: deliver VMAT prostate + nodes SABR in < 3 min
- Rationale: reduce intra-fraction motion for PACE-NODES trial patients, obey trial protocol
- Tools: RayStation (single arc, sliding window), 6MV FFF, Versa HD
- **Results**: Plan times between 3.2 and 3.6 minutes

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- **Conclusions**: close to 3min delivery is possible, plan quality maintained
- Take-aways: we do not optimise delivery time, but we can









