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TRAK as a patient-specific QA tool in gynaecological cancer brachytherapy

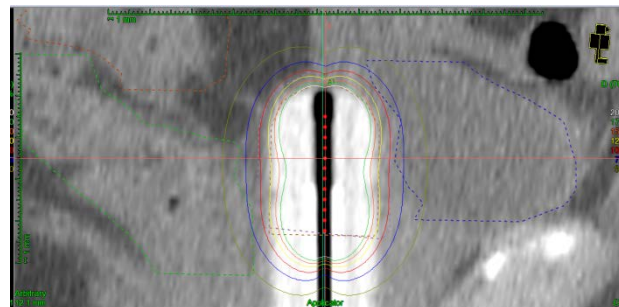
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Background

- TRAK (total reference air kerma rate)¹:
 - Integral of the reference air kerma rate at 1 m distance from the source over the duration of treatment
 - provides a useful patient-specific tool look at treatment intensity (analogous to MU in EBRT)
 - Limitations include: dose distribution, fractional dose, target volume or dose-rate



¹Nkiwane, K., et al. Brachytherapy, 16 (6):1184-1191 (2017)

Purpose

- Problem: TRAK used to check plan intensity individually
- Data driven TRAK-based metric to determine plan quality
- Take into account fractionation size and target volume (CTV)
- To summarise the expected TRAK values for
 - Vaginal vault
 - Interstitial and intracavitary cervix plans



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Equipment



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- 1x microSelectron Digital HDR/ V2-V3 afterloader (Fig 1)
- Source: solid Ir-192 activity of 370 GBq
- Oncentra Brachy for TPS
- Vaginal Segmented Cylinder Set for Vaginal Vault Tx (Fig 2)
 - Applicator diameter of 20 ,25 ,30 ,35 ,40 mm
- Interstitial Ring CT/MR Set for intracavitary or interstitial Cervix Tx (Fig 3)
 - Ring diameter of 26 ,30 ,34 mm
 - Tandem length of 20 ,40 ,60 mm



Fig 1

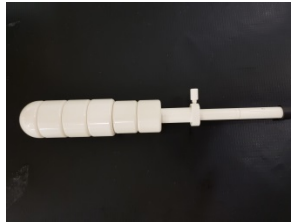


Fig 2



Fig 3 ²

²Fig 3 from Nucletron User Manual

Methods

- Vaginal Vault (n=136) and Cervix (n=110) plans from 2012-2017
- Plans were optimised to CTV D90 = 100% ($\pm 1\%$)³
- TRAK values were normalised to remove dependence of reference fractional dose d_{ref} (Gy) and target volume (cc)

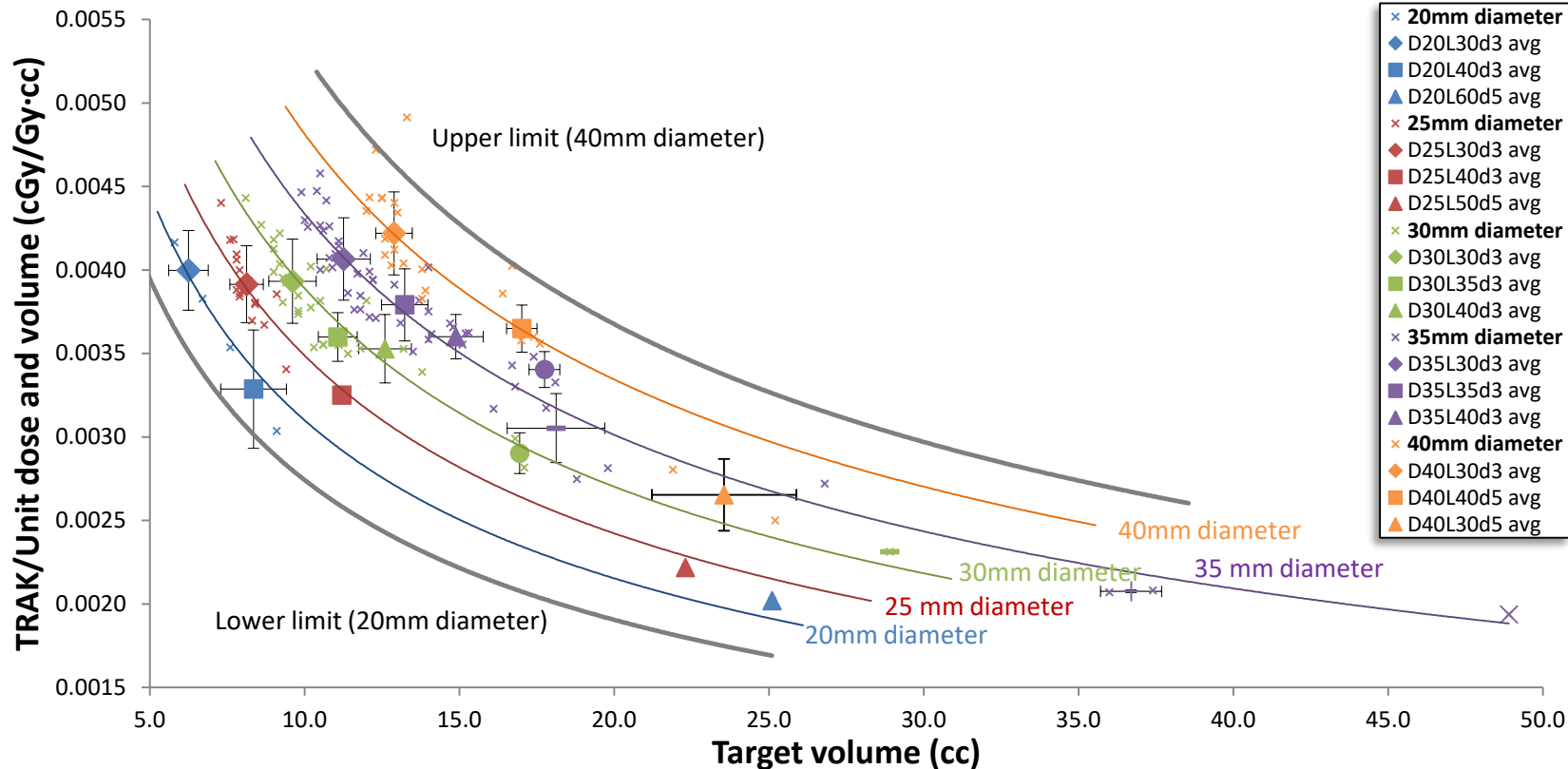
$$TRAK_{Normalised} = (TRAK (cGy)) / (d_{ref} (Gy) * target volume (cc))$$

- Outlier data points were removed
- $TRAK_{normalised}$ (cGy/Gy*cc) values were used as a function of target size (cc)

³Potter, R., et al. Clinical and Translational Radiation Oncology (2018)



Results: Vaginal Vault



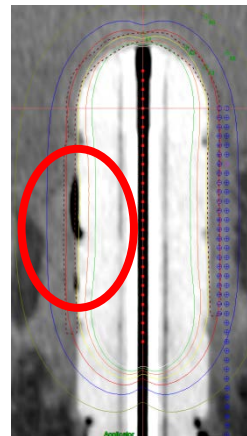
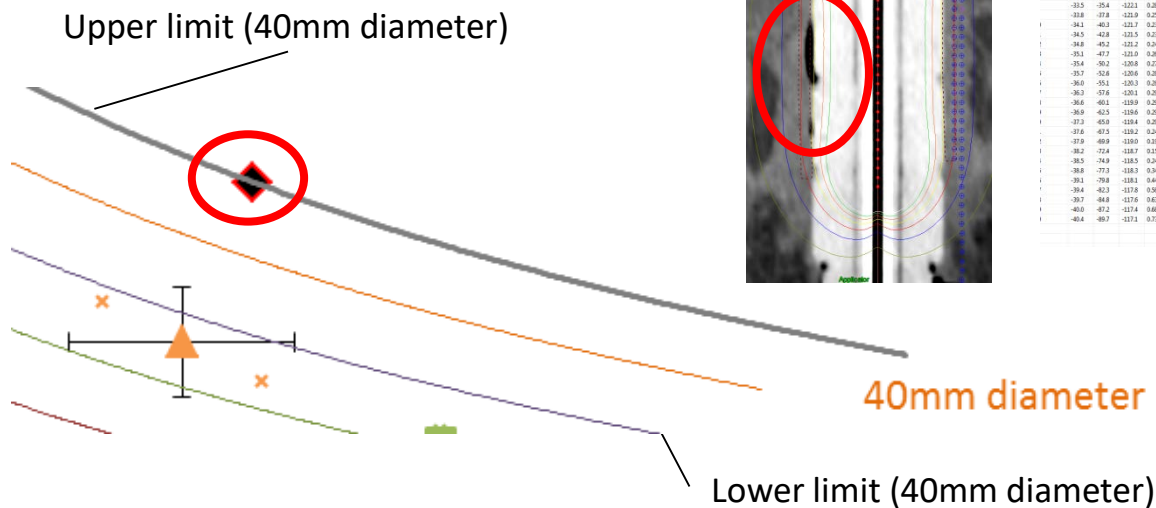
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Results: Vaginal Vault- prior to review



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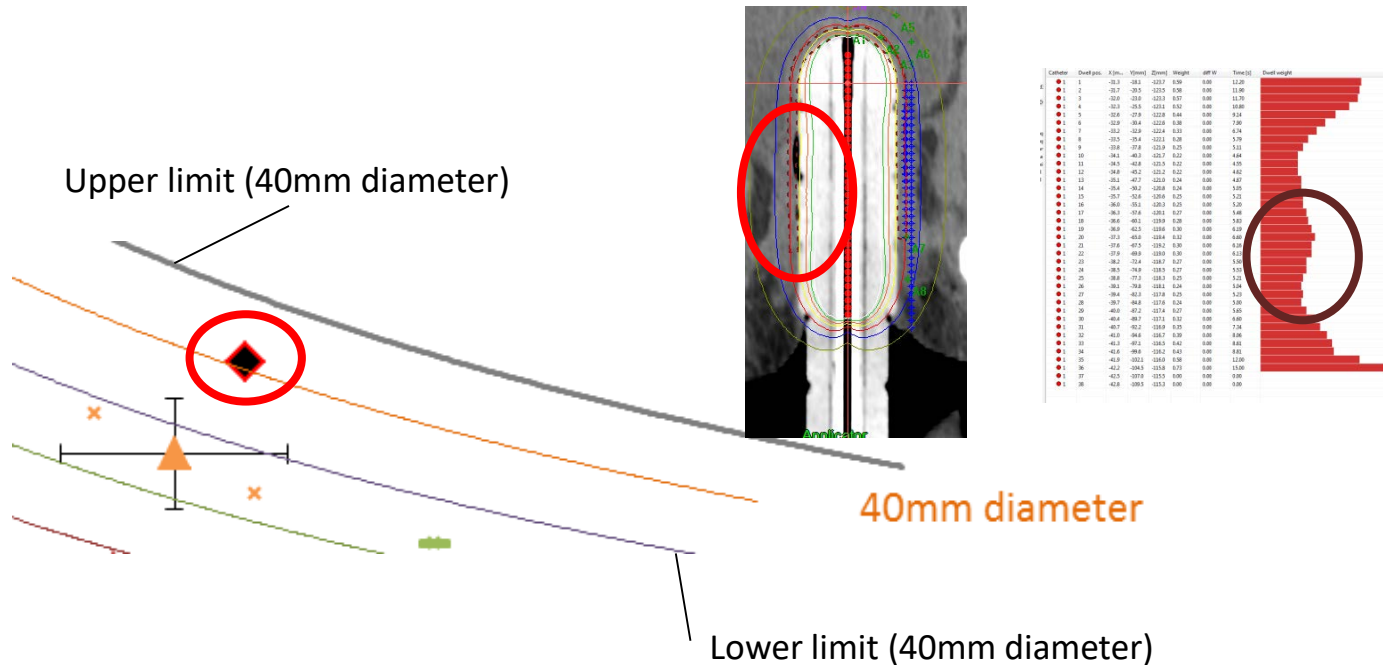


cell_pos.	X (mm)	Y (mm)	Z (mm)	Weight	d# W	Time (s)	Dwell weight
1	-31.3	-18.1	-121.7	0.37	0.00	11.87	
2	-31.7	-20.9	-123.5	0.30	0.00	12.20	
3	-32.0	-23.9	-123.3	0.58	0.00	11.90	
4	-32.3	-25.9	-123.1	0.52	0.00	10.80	
5	-32.6	-27.9	-122.8	0.44	0.00	9.14	
6	-32.9	-30.4	-122.6	0.38	0.00	7.90	
7	-33.2	-32.9	-122.4	0.31	0.00	6.14	
8	-33.5	-35.4	-122.3	0.28	0.00	5.79	
9	-33.8	-37.9	-122.9	0.25	0.00	5.13	
10	-34.1	-40.1	-121.7	0.23	0.00	4.70	
11	-34.5	-42.9	-121.5	0.23	0.00	4.70	
12	-34.8	-45.2	-121.2	0.24	0.00	4.90	
13	-35.1	-47.7	-121.0	0.26	0.00	5.30	
14	-35.4	-50.2	-120.8	0.27	0.00	5.60	
15	-35.7	-52.8	-120.6	0.28	0.00	5.80	
16	-36.0	-55.1	-120.3	0.28	0.00	5.75	
17	-36.3	-57.6	-120.1	0.28	0.00	5.65	
18	-36.6	-60.1	-119.9	0.29	0.00	6.0	
19	-36.9	-62.3	-119.6	0.29	0.00	6.0	
20	-37.3	-65.0	-119.4	0.29	0.00	6.0	
21	-37.6	-67.5	-119.2	0.24	0.00	5.0	
22	-37.9	-69.9	-119.0	0.29	0.00	4.4	
23	-38.2	-72.4	-118.7	0.15	0.00	3.20	
24	-38.5	-74.9	-118.5	0.24	0.00	5.00	
25	-38.8	-77.3	-118.3	0.34	0.00	7.00	
26	-39.1	-79.8	-118.1	0.44	0.00	9.13	
27	-39.4	-82.3	-117.8	0.58	0.00	12.00	
28	-39.7	-84.8	-117.6	0.43	0.00	11.00	
29	-40.0	-87.2	-117.4	0.68	0.00	14.00	
30	-40.4	-89.7	-117.1	0.73	0.00	15.00	

Results: Vaginal Vault- after review



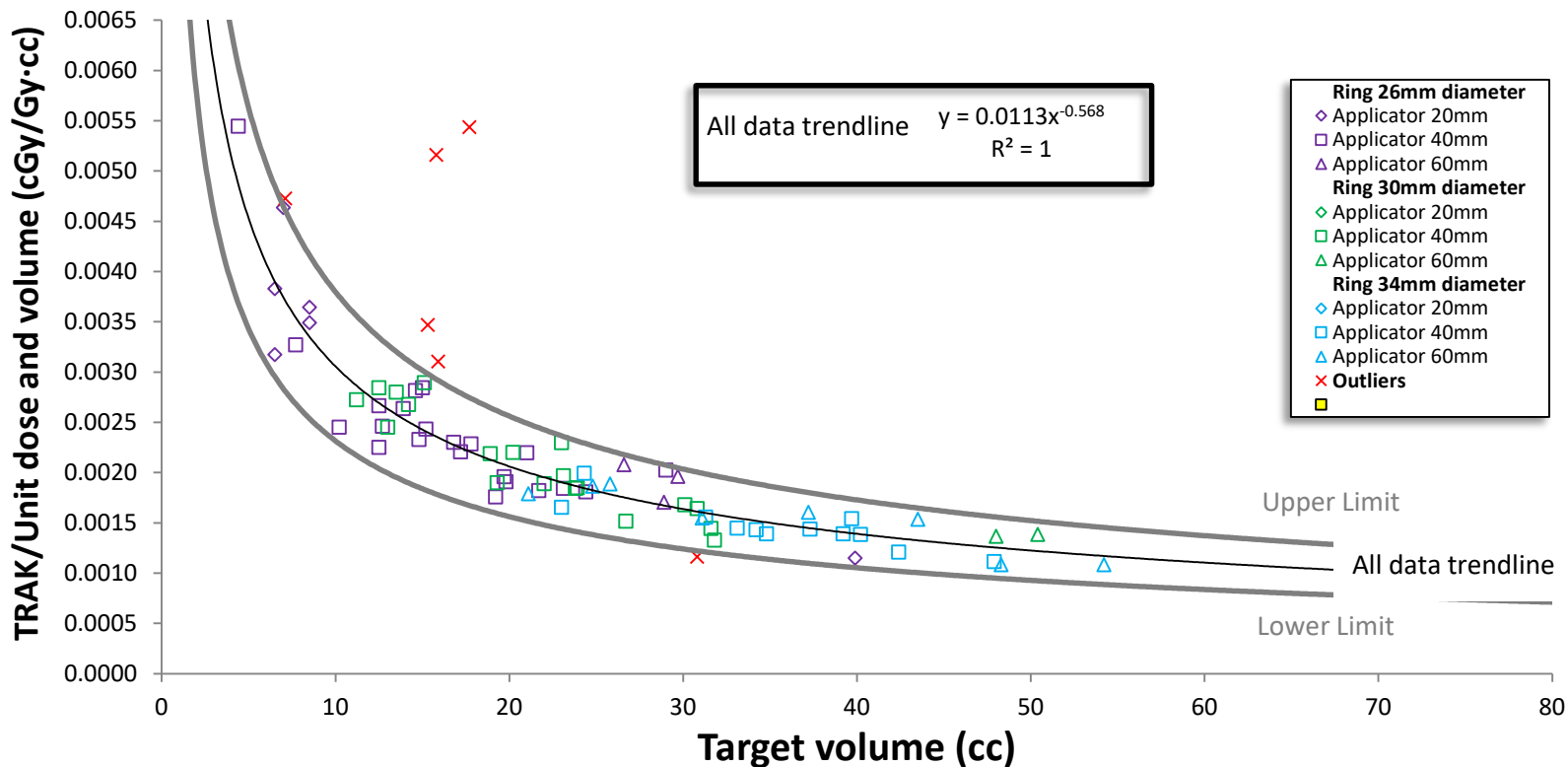
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Results: Intracavitary Cervix



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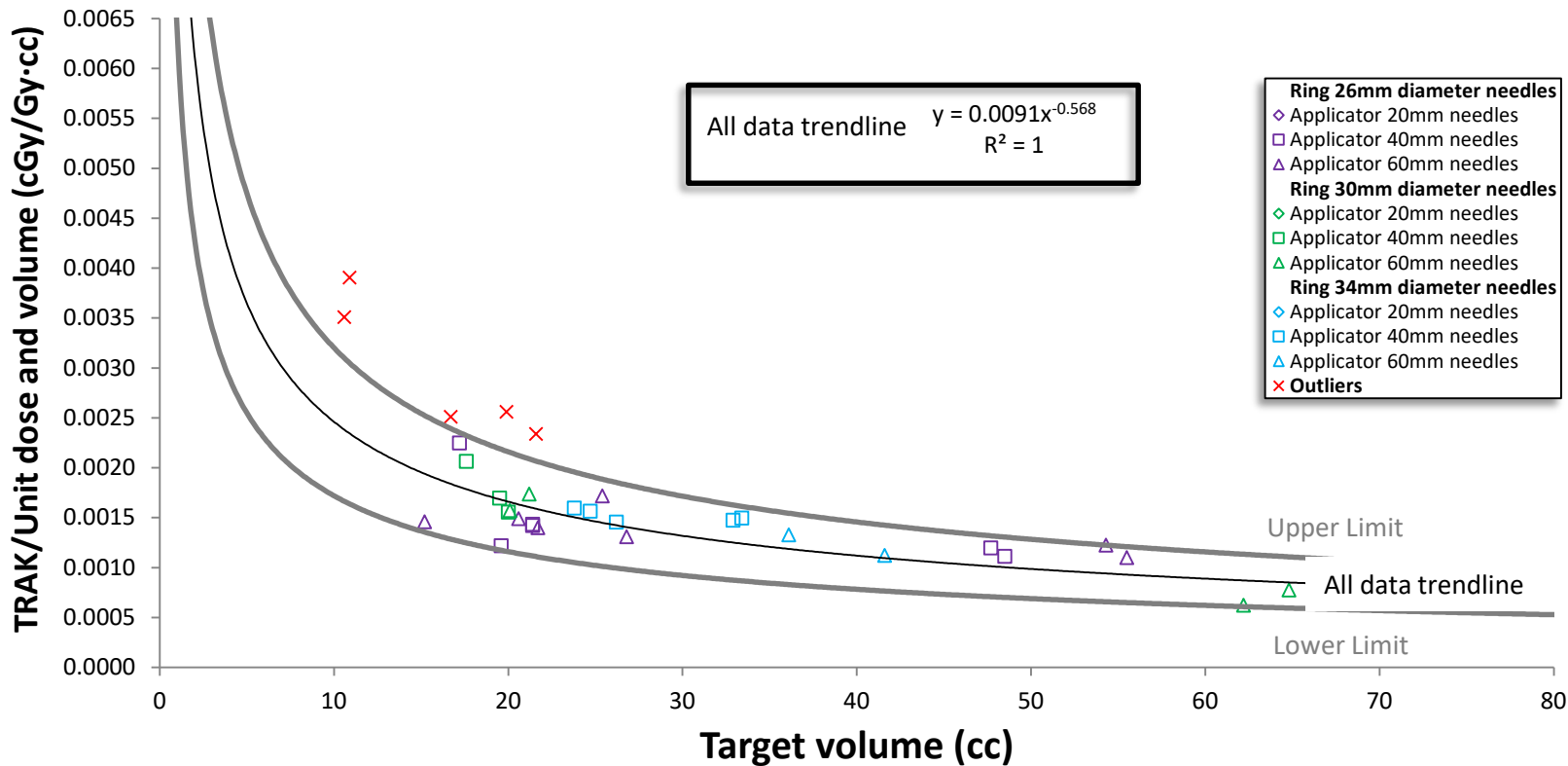


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Results: Interstitial Cervix



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Summary

- TRAK per unit reference dose and target volume successfully implemented for vault
- simple quality assurance tool to assess plan quality
- Future work:
 - Correlate patient outcomes (vaginal toxicity and nontoxicity) for Cervix Tx



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Thank you very much for your attention

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