



COMPARATIVE A STUDY OF HYBRID DYNAMIC CONFORMAL ARC THERAPY (DCAT) AND 3-DIMENSIONAL CONFORMAL RADIOTHERAPY (3D-CRT) FOR PROSTATE CANCER CASES.

Akaawa Nana Acquah¹, Prof. Eric K. T. Addison², Kingsley Akosah³, Eunice Arthur⁴, Joseph Gyasi⁵, Ruth Naa Momoekor Quaye⁶

¹Akaawa Nana Acquah, Department of Oncology, Medical Physics Unit, Komfo Anokye Teaching Hospital

²Prof. Eric K. T. Addison, Department of Oncology, Medical Physics Unit, Komfo Anokye Teaching Hospital

³Kingsley Akosah, Department of Oncology, Medical Physics Unit, Komfo Anokye Teaching Hospital

⁴Eunice Arthur, Department of Oncology, Medical Physics Unit, Komfo Anokye Teaching Hospital

⁵Joseph Gyasi, Department of Oncology, Medical Physics Unit, Komfo Anokye Teaching Hospital

⁶Ruth N. M Quaye, Department of Oncology, Medical Physics Unit, Komfo Anokye Teaching Hospital

1.1.1 ABSTRACT

Aim: The purpose of the study is to compare the dose characteristics of the hybrid dynamic arc therapy (DCA) and 3-Dimensional Conformal Radiation Therapy (3D-CRT) techniques for the treatment of prostate cancers using various indices to evaluate the quality of the plan and provide insights into the clinical implications of each approach.

Method: 20 prostate cancer cases planned with both DCA and 3D-CRT were analyzed. They were planned on the Varian eclipse system using both hybrid DCAT, a 360-degree rotation and 2 static beams, and 3D-CRT techniques for each case for adequate comparison.

Results and Discussion: There are strong similarities between hybrid and 3D-CRT as clearly observed in above in terms of conformity, dose distributions among OARs, Monitor Units and total PTV coverage. Regardless, Dynamic Conformal Radiotherapy with 360-degree arc only can readily be applied in palliative plans as it may be superior to 3D-CRT in terms of both conformation and speed of planning and delivery

Conclusion: Dynamic Conformal Arc Therapy (DCAT) is recommended to provide a useful substitute in some prostate cancer treatment planning situations which necessitate equal or a higher level of 3-dimensional

(3D) conformation than shaped static fields but for which Intensity Modulated Radiotherapy (IMRT) is inapplicable.

Keywords: Dynamic Conformal Arc, Dose, prostate, coverage.

1. INTRODUCTION.

Dynamic Conformal Arc Therapy is a radiation treatment planning technique in which the treatment beam is dynamically shaped with the utilization of multi-leaf collimators (MLCs) while the gantry rotates around the patient either fully or in an arc, allowing for a more conformal dose distribution to the tumour target while minimizing radiation exposure to normal tissues surrounding the tumour. 3D-conformal radiotherapy (3D-CRT) on the other hand uses three dimensional images to precisely target cancerous tumours and deliver calibrated radiation doses in multiple treatment sessions which is very similar to DCAT. Mostly, Dynamic Conformal arc therapy (DCAT) is applied where a high level of 3D conformation is needed without the complexity of Intensity Modulated Radiotherapy (IMRT) adjusting MLCs throughout the arc to closely match the shape of the tumor, providing better target coverage compared to conventional static beams. DCAT is a simplified form of volumetric modulated arc therapy (VMAT) with less complex beam modulation during the arc rotation. Similar to DCAT, 3D Conformal Radiotherapy is observed to reduce damage to surrounding normal tissues, deliver doses effectively, improve treatment outcomes to target volumes and minimize damage to normal tissues. Regardless of these tangible benefits, there are only a few studies on the comparison of DCAT to 3D-CRT. Most studies in DCAT are focused on the comparison of SBRT and VMAT to DCA for lung cancer treatment. This study, on the other hand, focuses on prostate as DCAT and 3D-CRT are observed to have better conformity outcomes with tumours with regular geometries due to conformity of the MLC leaves a predefined target shape during gantry motion or arcing. Also, the quality of the dose distribution produced by a DCAT is highly dependent on the specific patient geometry, due to lack of modulation. While most of the research on DCAT is geared towards the demographic of European or Caucasian patients, this research aims at considering the application of the DCAT technique on the African demographic of prostate patients as well as the comparison of 3D-CRT and DCAT techniques and their treatment planning outcomes with the objective of considering the implementation of this technique in the planning and treatment of prostate cancer patients at Komfo Anokye Teaching hospital.

2. METHODOLOGY

20 prostate cancer cases planned with both DCA and 3D-CRT were analyzed. They were planned on the Varian eclipse system using both hybrid DCAT, a 360-degree rotation and 2 static beams, and 3D-CRT techniques for each case for adequate comparison. For all 20 patients, the prescribed doses were 74Gy to 16 patients, 76Gy to 3 patients and 1 patient had a prescription of 78Gy.

3. RESULTS

3.1 OARs

The Mean Dose to the Organs at Risks were considered. The seminal vesicles received the highest doses due to its closeness to the prostate and was constant for DCA and 3D-CRT techniques. The Average Mean dose to the bladder was 37.949Gy in both DCA and 3D-CRT. There was a slight difference in the average Mean Dose to the rectum. 45.746Gy in 3D-CRT and 44.283Gy in DCA. The average Mean doses for the femoral head were 36.657Gy and 36.506Gy for the left and right femoral heads respectively for DCA. For 3D-CRT the left and right femoral head received an average mean dose of 34.513Gy and 32.832Gy to the left and right femoral head respectively

3.2 Target Coverage

All 20 prostate cancer cases had good coverage but averagely the percentage of dose coverage for the PTVs in the DCA plans was 92.07% with the 3D-CRT plans having 92.38% coverage. The MUs for both techniques were observed to be 324.5 and 322.5 for DCA and 3D-CRT respectively.

3.3 PTV

The PTVs considered were within a 151.30cm³ (lowest) and 444.30cm³ (highest) volume. Most PTVs were about 250cm³ and quite defined with very a few irregularities to their shapes.

4. DISCUSSION

Hybrid DCAT is observed to achieve better conformation than static field approaches. Dynamic Conformal Radiotherapy with 360-degree arc only can readily be applied in palliative plans as it may be superior to 3D-CRT in terms of both conformation and speed of planning and delivery. While there are strong similarities between hybrid and 3D-CRT as clearly observed in above in terms of conformity, dose distributions among OARs, Monitor Units and total PTV coverage; these two treatment planning procedures have a disadvantage of not delivering good dose conformity to the few irregularly-shaped tumours but better performance was detected when applied to tumors with well-defined shapes.

5. CONCLUSION

Dynamic Conformal Arc Therapy (DCAT) is recommended to provide a useful substitute in some prostate cancer treatment planning situations which necessitate equal or a higher level of 3-dimensional (3D) conformation than shaped static fields but for which Intensity Modulated Radiotherapy (IMRT) is inapplicable.

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7. APPENDIX

Table 1. A table representing the mean doses received by the various Organs at Risk (OARs) using the Dynamic Conformal Arc Technique.

TOTAL DOSE (GY)	PTV (cm ³)	DCA	DCA	DCA	DCA	DCA	DCA	DCA
		Seminal Vesicle	Bladder	Rectum	Femoral Head (L)	Femoral Head (R)	PTV Coverage (%)	MU 1
74	151.3	76.22	19.72	27.75	33.58	33.01	87.2	333
74	219.6	76.47	33.34	45.49	48.46	49.4	86.5	325

74	219. 2	75.45	43.23	49.78	45.65	49.89	84.4	324
74	183. 4		48	50.8	47.34	46.36	83.1	290
74	236. 6	73.01	12.78	40.7	47.77	44.08	87.9	266
74	125. 9		21.65	38.04	25.56	27.27	93.4	337
74	379. 1	43.47	67.62	40.69	40.69	40.52	93.6	314
74	218. 9	75.94	19.53	43.65	33.67	29.09	94.5	312
74	197. 6		50.1	58.3	41.4	41.1	94.1	334
74	444. 3	75.35	45.4	58.27	31.21	32.29	92.8	319
74	255. 2	75.04	28.22	33.64	31.2	30.56	95.4	352
74	214. 1	75.21	20.27	49.86	23.43	27.37	96.7	336
74	113. 7	75.85	19.75	36.77	35.17	32.9	97	318
74	227	75.36	58.6	41.31	32.8	31.28	96.9	338
76	204. 1		27.15	52.13	32.78	32.49	95.8	313
76	403. 2	71.58	54.38	47.12	41.91	40.23	93.2	327
76	137. 6		48.87	43.97	35.21	31.67	96.9	356
78	187. 7	78.17	44.28	44.24	31.67	32.22	96.7	344
74	160. 2	75.15	13.64	41.33	41.96	43.78	79.5	330
74	166. 7	75.2	18.08	41.81	31.67	34.6	95.8	322
AVERAG E		73.164666 67	37.94 85	44.28 25	36.656 5	36.505 5	92.07	324. 5

Table 2. A table representing the mean doses received by the various Organs at Risk (OARs) using the 3-Dimensional Conformal Radiotherapy Technique.

3D	3D	3D	3D	3D	3D	3D
Seminal Vesicle 2	Bladder 2	Rectum 2	Femoral Head (L) 2	Femoral Head (R) 2	PTV Coverage (%) 2	MU 2
77.48	23.46	30.72	25.42	25.52	94	309
76.8	43.2	52.03	40.38	37.91	97.5	320
76.48	49.29	54.75	36.76	34.24	91.2	325

	56.49	55.6	38.25	39.74	90.7	380
75.67	16.55	42.62	31.33	35.39	90.2	370
77.72	25.75	36.82	31.64	27.32	90.1	316
	45.06	53.38	42.1	4.02	71.5	346
76.97	41.13	41.13	32.74	40.77	94.7	289
	42.04	41.92	50.38	35.46	96.7	305
78.08	46.55	54.11	33.39	31.79	87	322
	35.73	35.17	28.04	28.73	95.9	358
76.84	23.41	49.6	27.63	25.38	96.4	321
76.13	21.11	38.57	29.75	30.82	99	277
77.5	58.42	41	29.61	33.1	84.8	313
0	29.61	50.88	28.95	30.69	95.3	294
77.01	58.55	51.13	34.66	38.44	94.8	302
	54.1	45.95	51.47	50.23	96.1	366
79.32	50.18	48.47	31.92	35.61	97.5	312
76.39	17.15	47.96	37.89	39.17	90.2	288
76.78	21.19	43.11	27.95	32.3	94	337
71.94466667	37.9485	45.746	34.513	32.8315	92.38	322.5

Fig 1. A Graph representing the PTV Coverage for 20 prostate cancer cases planned with both DCAT and 3D-CRT.

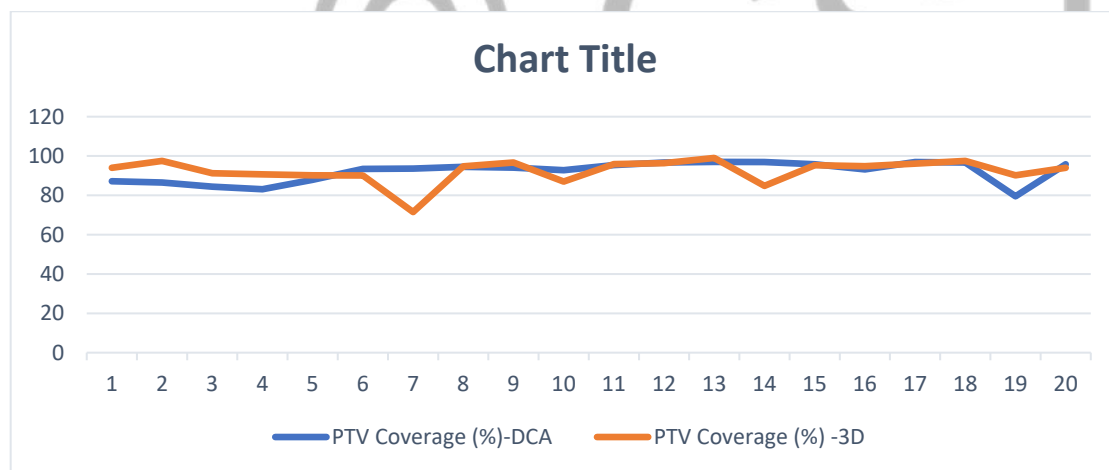


Fig 2. A Graph representing the Mean Doses received by the rectum for 20 prostate cancer cases planned with both DCAT and 3D-CRT.

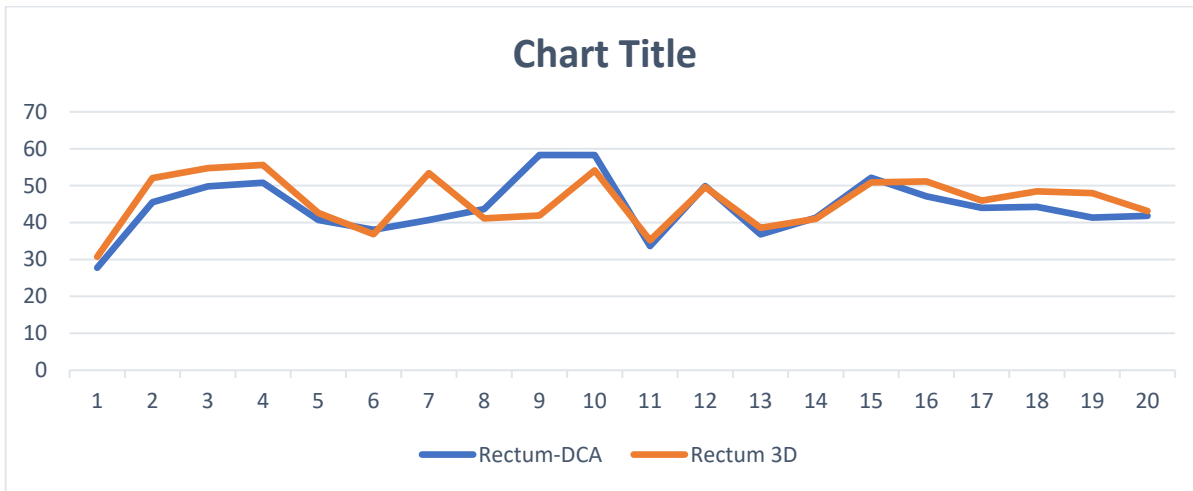


Fig 3. A Graph representing the Mean Doses received by the Bladder for 20 prostate cancer cases planned with both DCAT and 3D-CRT.

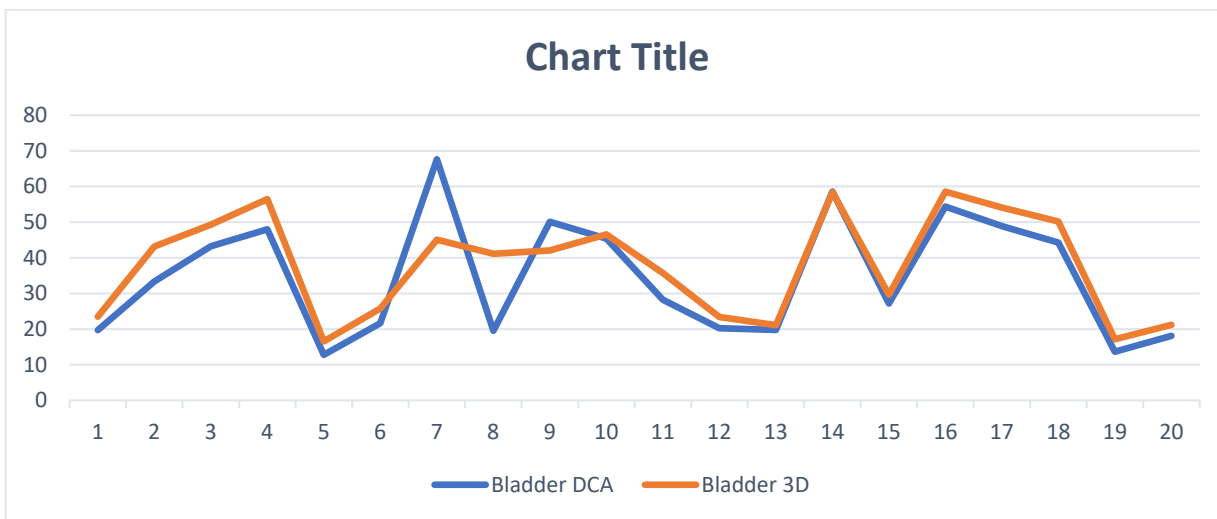
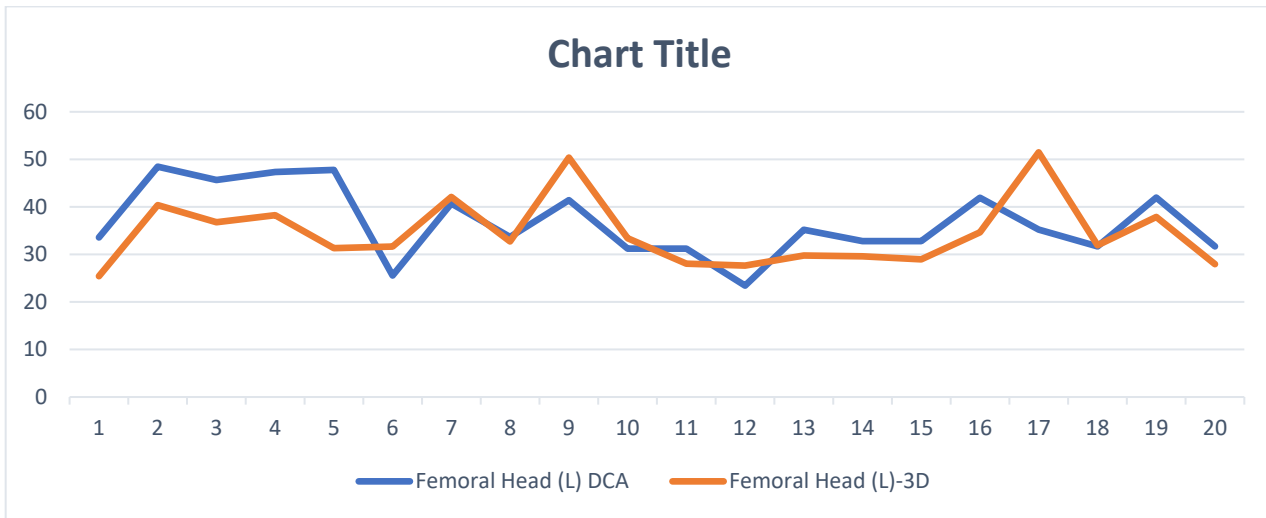


Fig 4. A Graph representing the Mean Doses received by the Left Femoral heads for 20 prostate cancer cases planned with both DCAT and 3D-CRT.



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Fig 5. A Graph representing the MUs from the planned cases of 20 prostate cancer cases planned with both DCAT and 3D-CRT.

