The Comparison of Collapsed Cone and Monte Carlo Algorithms in Tangential Breast Planning

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Introduction: AHN currently uses Elekta's Monaco Collapsed Cone (CC) dose calculation algorithm for tangent breast treatment planning due to the confidence in CC in terms of dose accuracy within an acceptable margin and due to the historically long computational time needed for Monte Carlo (MC) calculation. With new quality metrics AHN has adopted for evaluating tangent breast plans along with a decrease in calculation time and therefore an increase in clinical viability for using MC, it is necessary to evaluate the dose accuracy associated with MC vs. CC treatment planning.

Background: Breast planning at AHN can be categorized into three historical eras of planning. First generation; no target, qualitative evaluation, global hotspot<110%. Second generation; target contoured, coverage >95% of the target receiving at least 95% Rx dose, global hotspot between 105-107%. Third (current) generation; standardized target definition, coverage >95% of the target receiving at least 95% Rx dose, global hotspot between 105-107%, DVH-based OAR metrics: Heart mean <200cGy, Thyroid max <2% Rx, Ipsilateral Lung V20Gy <15%, Contralateral Lung V5Gy <15%, V105% Rx <10% PTV

Methods and Materials: 13 clinically treated Tangent Breast plans were identified. All plans used FiF technique and were calculated with Collapsed Cone using Elekta's Monaco 5.5. All plans were then recalculated using Monte Carlo using the same MU and leaf/beam patterns. Isodose distributions were observed (Fig.1), PTV dose metrics and Ipsilateral Lung V20Gy were evaluated (Fig. 2). The calculation time was also documented for CC vs. MC plans. Four of the 13 plans used in the study were delivered onto the SNC ArcCheck QA phantom and analyzed for Quality Assurance using 2%2mm and 3%3mm γ-analysis (Table 2).

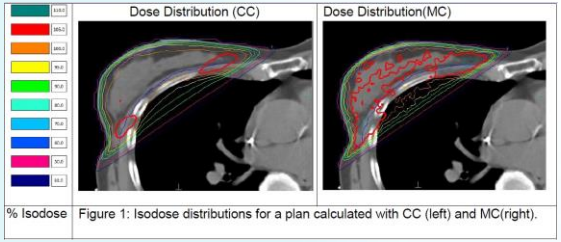

Figure 1: Isodose distributions for a plan calculated with CC (left) and MC(right).

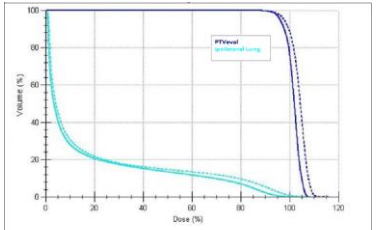

Figure 2: Dose Volume Histogram for a plan calculated using CC (solid) and recalculated using MC(dashed).

Results: PTV D95% and V95% showed a variation of 3% or less between the CC and MC plans, while the PTV V100% and Ipsilateral Lung V20Gy showed slightly higher variations (Table 1). PTV V105% showed the highest variation, of up to a 593% increase with MC. This extreme increase can be explained by the steepness of the DVH curve at this point (Fig.3). The time necessary to perform calculations was longer for each CC plan than for the same plan that had been recalculated using MC. Also, QA pass rates using 2%2mm as well as 3%3mm gamma criteria for each CC plan were lower than for the same plan recalculated using MC (Table 2).

Table 1: Results of initial Collapsed Cone vs. recalculated Monte Carlo Plans

	Collapsed Cone					Monte Carlo					Difference					
Patient	V95%	D95%	V100%	V105%	IpLng V20Gy	V95%	D95%	V100%	V105%	IpLng V20Gy	V95%	D95%	V100%	V105 %	IpLng V20Gy%	IpLng V20Gycc
1	99.98	4266.90	96.03	9.070	10.06	100.0	4267.7	95.90	36.87	10.6	-0.01	0.02	-0.16	306.50	4.87	0.49
2	98.13	4164.20	90.00	14.27	0.90	97.8	4177.7	92.00	53.21	1.0	-0.32	0.32	2.18	272.88	15.56	0.14
3	97.55	4933.50	89.87	33.15	16.02	95.3	4801.3	84.10	32.55	16.4	-2.35	-2.68	-6.48	-1.81	2.62	0.42
4	97.19	4806.10	77.04	9.97	15.16	98.3	4885.3	88.80	41.56	16.1	1.14	1.65	15.21	316.85	5.87	0.89
5	97.25	4134.70	87.10	9.16	2.20	96.5	4102	85.60	15.90	2.4	-0.78	-0.79	-1.75	73.58	8.18	0.18
6	98.58	4179.70	89.67	9.43	9.27	98.3	4193.5	92.00	39.12	9.7	-0.27	0.33	2.58	314.85	4.10	0.38
7	99.46	4266.40	95.47	10.63	6.43	99.1	4272.7	95.80	41.14	6.9	-0.35	0.15	0.31	287.02	6.84	0.44
8	95.23	4759.20	81.19	13.35	13.24	97.1	4853.4	89.40	36.95	13.6	1.95	1.98	10.14	176.78	2.34	0.31
9	100.00	4137.90	98.70	18.72	6.17	100.0	4148.6	98.90	47.69	6.5	0.00	0.26	0.15	154.75	4.70	0.29
10	99.64	4197.10	85.00	7.98	10.77	99.2	4219.2	91.20	22.56	11.2	-0.41	0.53	7.28	182.71	3.71	0.40
11	98.85	4153.40	83.55	5.48	1.21	98.9	4181.9	88.40	20.66	1.3	0.06	0.69	5.80	277.01	9.92	0.12
12	74.57	4594.10	38.72	10.20	16.45	79.4	4601.5	46.70	21.34	17.0	6.41	0.16	20.48	109.22	3.59	0.59
13	99.43	3930.00	85.29	2.33	5.76	99.5	3927.1	84.60	16.16	6.1	0.07	-0.07	-0.81	593.56	6.25	0.36
AVE											0.40	0.20	4.23	235.68	6.04	0.39

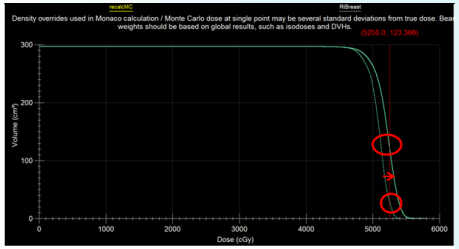

Figure 3: Change in V105 with increase in dose associated with Monte Carlo recalculation

Table 2: QA pass rate	Collapsed Cone QA pass rate		Monte Carlo QA pass rate	
Patient	2%2mm	3%3mm	2%2mm	3%3mm
1	74.7	95.4	96.3	100.0
7	62.3	87.8	79.0	94.2
12	74.0	90.2	94.5	99.5
13	88.8	98.6	96.2	99.4
AVE	68.5	91.6	87.7	97.1

Conclusion: Our study showed that it is highly likely that PTV V105% values are in reality significantly higher than the values presented when the Collapsed Cone dose calculation algorithm is used in planning. Because this metric is often used as a benchmark for acceptability of plan quality and a predictor of toxicity, and because computational power and associated calculation time for Monte Carlo is no longer prohibitive, we can suggest that Monte Carlo be used as the standard dose calculation algorithm for tangent breast planning. Further study is needed to investigate the relationship between the severities (grade) of these effects with a potentially more accurate measure of the PTV V105%. Time for calculation and higher QA pass rates indicate a shift in paradigm for planning breast cases which may be desirable.