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Dosimetric Comparison and Plan Evaluation of Different Dose Computing Algorithms for Different Radiotherapy Techniques in Head and Neck Tumors

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ABSTRACT

Introduction: The study aims to compare target coverage and critical structure dose difference between various dose computing algorithms with small segment dose calculation in Intensity Modulated Radiation Therapy (IMRT) and large segment dose calculation in 3-Dimensional Conformal Radiation Therapy (3DCRT) treatment plan for Head and Neck (H&N) tumor.

Material and Methods: For the present study, thirty-eight H&N cancer patients were selected retrospectively. Twenty-seven patients were planned with IMRT plan using Monte Carlo (MC) algorithm and eleven patients with 3DCRT plan using Collapsed Cone/Superposition (CCS) algorithm. IMRT plan was recalculated with Pencil Beam (PB) and the 3DCRT plan was recalculated with MC and PB algorithms. An Independent student t-test was performed as a part of statistical analysis for dosimetric comparison of the p-value.

Results: In the IMRT plan, mean dose, Conformity Index (CI), $D_{2\%}$, $D_{98\%}$, and $D_{50\%}$ showed a significant difference in p-values ($p<0.05$), but the critical structure did not have a significant difference in p-value between the MC and PB algorithms, except Planning Risk Volume (PRV) spine. In the 3DCRT plan, mean dose, CI, Homogeneity Index (HI), $D_{98\%}$, $D_{50\%}$ and all the critical structures showed no statistically significant p-values ($p<0.05$) between the CCS with MC and CCS with PB algorithms.

Conclusion: The study concludes that in the IMRT treatment technique, PB algorithms overestimate the dose compared to the MC algorithm, even in the head and neck treatment area. For 3DCRT treatment plans, CCS, MC, and PB algorithms showed no statistically significant differences between them. Moreover, this study ensured the accuracy of various dose calculation algorithms in H&N radiotherapy.

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Introduction

Head& Neck cancer is one of the familiar cancers occurring worldwide. The most common etiology for head& neck cancer is the use of oral tobacco, which is very prevalent in the Indian subcontinent. Other risk factors are alcohol consumption, smoking, and sharp tooth [1]. The sub-sites for head& neck cancer are the nasopharynx, oral cavity, oropharynx, glottis, and hypopharynx [2]. The most familiar histology is squamous cell carcinoma. Treatment of H&N cancers involves different modalities like surgery, chemotherapy, and radiotherapy, of which radiotherapy plays a major role [3,4].

Dose calculation precision in Treatment Planning System (TPS) depends on the algorithms used for dose computing. If there is a small uncertainty in the dose calculation algorithm, it will significantly impact treatment plan generation and the accuracy of the treatment plan[5].An ideal treatment planning algorithm should be capable of measuring the actual dose with maximum precision. Since different algorithms have different dose calculation characteristics, the dose distribution will differ in each of them.

Treatment delivery is independent of algorithms used in the TPS, but the dose estimated by the different algorithms needs to be the same for all the TPS. Dose accuracy is usually similar when algorithms are applied to homogeneous treatment areas, but in a heterogeneous medium, like lung tumors, the calculated dose is different from the treatment delivered dose. Although many literatures is available on the comparison of dose calculation algorithms in

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heterogeneous mediums, the results have concluded that the MC algorithm gives an accurate treatment plan, and there were significant dose differences in Pencil beam (PB) algorithms [6-9].The PB algorithm usually overestimates the dose compared to MC and Collapsed Cone (CC) algorithms. The PB algorithms have some disadvantages compared with the other algorithms. The PB algorithms do not account for photon scatter and electron transport from the heterogeneous treatment area. When the tumor is located near the bony or air cavity area, the PB algorithm overestimates the dose [10,11].

The American Association of Physicists in Medicine (AAPM) Report No.105 explains the implementation of MC algorithms in radiotherapy treatment planning for electron and photon [12]. This report identified some issues faced while using MC algorithms in a clinical setting, such as treatment head simulation, patient simulation, and experimental verification. The MC algorithms give more accuracy and speed in dose calculation [13]. To evaluate the beam algorithms, specific acceptance and quality assurance (QA)tests were designed to achieve the characteristic of the convolution superposition (CS) Model [14,15].

The small segments in the Intensity Modulated Radiation Therapy (IMRT) treatment plan also contribute to the dose calculation difference between the different algorithms. This study aims the comparison of dose calculation accuracy for different algorithms between the small segments (IMRT treatment plan) and open field (3DCRT treatment plan).

Materials and Methods

Patient selection

Thirty-eight patients were chosen retrospectively for this study who underwent sequential IMRT and 3DCRT treatment technique with curative intent from January 2017 to August 2021 in our centre. The first group consisted of seventeen patients with primary glottis, oropharynx, hypopharynx, Carcinoma Unknown Primary (CUPS) and oral cavity treated with radical radiation therapy by sequential IMRT technique. The total dose planned for this group of patients is 70Gy in 35 fractions, which was delivered sequentially as phase1 50Gy in 25 fractions, followed by phase2 10Gy in 5 fractions and phase3 10Gy in 5 fractions. . The second group consisted of ten patients with a primary oral cavity treated with adjuvant radiation therapy by sequential IMRT technique. The dose planned for this group of patients is 60Gy in 30 fractions, which was delivered sequentially as phase1 50Gy in 25 fractions, followed by phase2 10Gy in 5 fractions The third group includes eleven patients treated with a primary oral cavity adjuvant radiation therapy by sequential 3DCRT technique. The total dose planned for this group of patients is 60Gy in 30 fractions, which was delivered sequentially as phase1 50Gy in 25 fractions, followed by phase2 10Gy in 5 fractions).

Patient Simulation and Contouring

Patients were positioned supine with their necks in a neutral posture using a suitable headrest and immobilized using a customized thermoplastic mask. The simulation was carried out on a General Electric (GE) health care planning Computed tomography (CT) scanning machine. For IMRT, the simulation was performed at an interval of 2.5 mm and the slice thickness of 2.5mm from vertex to T8 vertebra. Similarly, for 3DCRT, the simulation was performed at an interval of 5.0 mm and the slice thickness of 5.0 mm. The delineation of critical structure and target volume was done as per the Radiation Therapy Oncology Group (RTOG) guidelines by the clinician.

Treatment Planning

Treatment plans were planned using Monaco^{TM} TPS version 5.11.03 software with 6MV Photon beams. The treatment plans were planned to treat the patients in the Elekta synergy platform, having 40 pairs of Multi-Leaf Collimator (MLC) and leaf thickness of 1cm at the isocenter.The IMRT treatment plans were done using step and shoot MLC using nine co-planar beams. A total of 27 patients underwent the IMRT plan, of which 17 were radical radiation therapy and ten adjuvant radiation therapy patients. The IMRT treatment plan was initially planned with the MC algorithm and recalculated with the same monitor unit's (MU) using the PB algorithm. For the 11 adjuvant radiation therapy patients, 3DCRT treatment plans were planned with the CCS algorithm, and the same plans were recalculated with MC and PB algorithms.

Plan Comparison and Evaluation

The plan evaluation was done for the target coverage using an isodose color wash qualitatively in the axial, coronal, and sagittal slices. For the plan to be analyzed quantitatively, Planning Target Volume (PTV) mean dose, CI, HI, V_{95}% (volume received by the 95% of the prescribed dose), V_{107}% (volume received by107% of the prescribed dose) and Organ At Risk (OAR) dose analysis was done with Dose Volume Histogram (DVH). For parallel organ dose, the mean dose and 50% of the parotid dose were analyzed. For serial organ dose, spinal cord and brainstem analysis was done with dose received to 1cc volume of the serial organ. The Dose coverage to the target was analyzed and recommended by the International Commission Radiation units ICRU 83 report [16,17], and the dose evaluation indexes are CI & HI.

Conformity index (CI)& Homogeneity index (HI)

The CI&HI were calculated for this study as follows[9]

CI = volume of the reference dose (VR) / total volume of the target (VT)

HI = D_{98}% / D_2%

Where,

D_2% - Maximum dose near PTV (PTV Volume receiving 2% of Dose)

D_{98}% - Minimum dose near PTV (PTV Volume receiving 98% of Dose)

The absolute value for CI & HI is 1. The CI & HI were defined in many ways in the literature [18,19].

Quality Assurance

The IMRT QA procedure was done with the I'Matrixx dose verification system (IBA, Germany) for both MC and PB algorithms using the I'Matrix device, having one thousand twenty air-vented ionization chambers [20]. The IMRT QA plans were generated for each IMRT treatment plan in the Monaco^{TM} TPS for both MC and PB algorithms. The fluence calculated for both algorithms were compared with its respective measured fluence in the Omnipro software [21]. The gamma passing analysis was done with Gamma 3.0 %, 3mm, Distance to Agreement (DTA), and correlation coefficient. For the IMRT treatment, patient cohort quality assurance was done, and the QA pass rate between the MC and PB algorithms were compared.

Statistical Analysis

Independent student t-test statistical analysis were performed for IMRT patient groups to all the PTV and OAR for MC and PB algorithms [22]. For 3DCRT patients, the same test was performed to PTV and OAR for CCS with MC and CCS with PB algorithms. The statistical significance threshold value was kept at less than $p<0.05$ for the entire test performed in this study.

Results

Dose distribution in the PTV, mean dose, HI, CI, and OAR dose were calculated from the DVH for the different dosimetric algorithms and treatment planning techniques. Figure 1.1 shows a comparison of isodose distribution between MC and PB algorithms for the radical IMRT patient plan. Figure 1.2 shows a comparison of isodose distribution between MC and PB algorithms for the adjuvant IMRT patient plan. Figure 1.3 shows a comparison of isodose distribution between CCS and MC algorithms for the adjuvant 3DCRT patient plan. Figure 1.4 shows a comparison of isodose distribution between CCS and PB algorithms for an adjuvant 3DCRT patient plan.

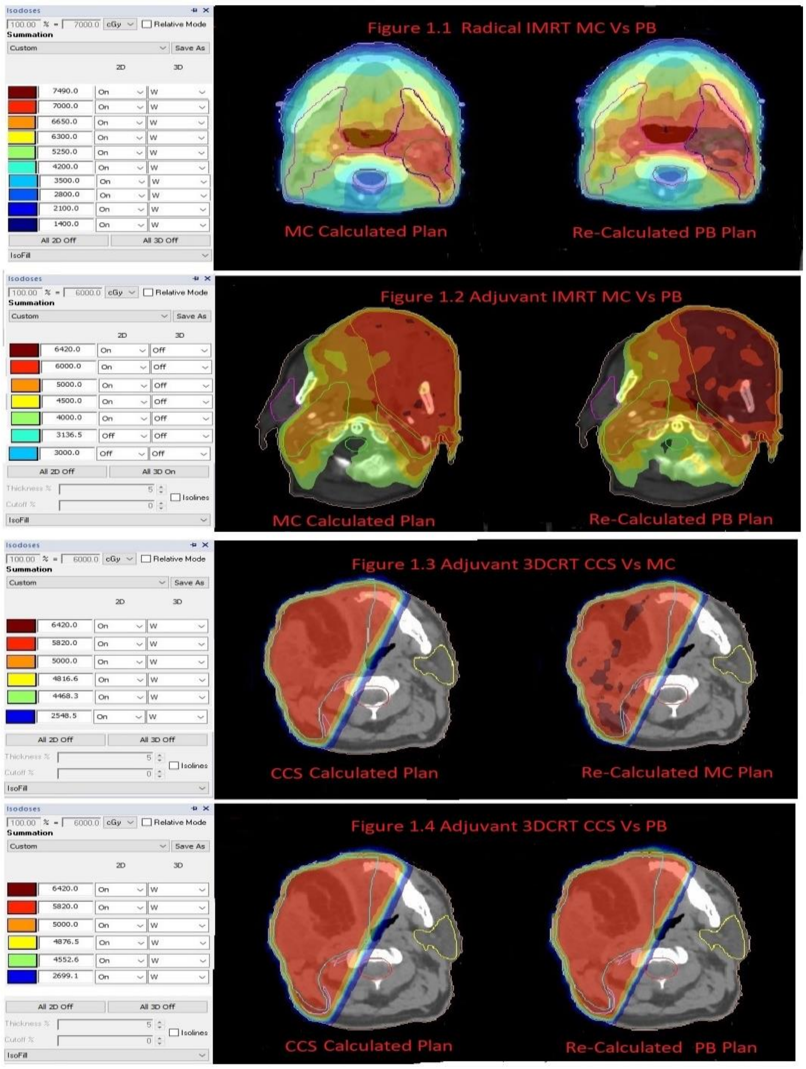

Figure 1.Comparison of isodose distributions for different algorithms with different technique.

Radical IMRT-PTV

Summary of Radical patients IMRT treatment plan PTV 70Gy, PTV 60Gy, and PTV 50Gy comparison for MC and PB algorithms were tabulated in Table 1. For PTV70 treatment volume, the mean dose, CI, $D_{2\%}$, $D_{98\%}$ and $D_{50\%}$ showed there was a statistically significant difference p values (p<0.000) between the MC and PB algorithms, except HI (p-value =0.65). For PTV60 treatment volume as well, the results show that statistically significant differences were obtained between the MC and PB algorithms, except for the HI (p-value=0.552). For PTV50 treatment volume, mean dose, and conformity index showed there was a statistically significant p values (0.01 and 0.002) difference between the MC and PB algorithms; other parameters HI, $D_{2\%}$, $D_{98\%,}$ and $D_{50\%}$ showed no statistically significant p values (0.518, 0.050, 0.067 and 0.167) difference between the PB and MC algorithms. The PB algorithms showed an increased mean dose and Dmax to the PTV.

Radical IMRT-OAR'S

Summary of radical IMRT treatment plan OARs dose received by the MC and PB algorithms were tabulated in Table 2. PRV spine had a significant difference p-value (p<0.000), but other critical structures; right parotid mean dose, right parotid 50 % dose, left Parotid, left parotid 50 % dose, and brain stem, did not have a statistically significant difference p-value (0.101, 0.450, 0.135, 0.421 and 0.384) between the MC and PB algorithms. Figure 2 shows the comparison of radical IMRT treatment plan DVH for MC and PB algorithms.

Adjuvant IMRT-PTV

Results of Adjuvant patient's IMRT treatment plan PTV60 and PTV50 comparison between the CCS and PB Algorithms were tabulated in Table 3. For PTV60 treatment volume, the mean dose, CI, HI, $D_{2\%}$, $D_{98\%,}$ and $D_{50\%}$ showed that there was a statistically significant difference in p-value (p<0.000)between the MC and PB algorithms. For PTV 50 treatment volume, the mean dose, CI, D_2, $D_{98,}$ and D_{50} showed there was a statistically significant difference in p-value (p<0.000, 0.028, 0.000, 0.002 and 0.000) between the MC and PB algorithms, except HI (p-value 0.156).

Adjuvant IMRT-OAR'S

Comparison between MC and PB algorithms adjuvant IMRT treatment plan OARs doses were tabulated in Table 4. PRV spine had a statistically significant p-value (p=0.001), but other critical structures; Contralateral Parotid mean dose, Contralateral parotid 50 % dose, and brain stem, showed a statistically insignificant p-value (0.064, 0.225, and 0.268) between the MC and PB algorithms. Figure 3 shows the comparison of adjuvant IMRT treatment plan DVH for MC and PB algorithms.

Table 1. Radical IMRT treatment plan dosimetric data comparison for PTV (± shows Standard Deviation, * shows statically significant values)

Parameter	PTV 70			PTV 60			PTV 50		
	MC	PB	P value	MC	PB	P Value	MC	PB	P Value
Mean Dose	72.19±0.35	75.34±0.68	0.000*	66.51±1.16	69.53±0.98	0.000*	56.89±2.36	59.27±2.72	0.010*
Conformity Index (CI)	0.984±0.0111	0.989±0.0016	0.000*	0.994±0.0058	0.999±0.0015	0.007*	0.995±0.0042	0.991±0.0013	0.002*
Homogeneity Index (HI)	1.089±0.0209	1.092±0.0117	0.650	1.228±0.3094	1.222±0.0284	0.552	1.359±0.0770	1.377±0.0834	0.518
D2%	74.15±0.51	78.14±0.97	0.000*	72.77±0.46	76.11±0.86	0.000*	68.41±3.70	71.19±4.25	0.050*
D98%	68.09±1.2	71.57±0.80	0.000*	59.29±1.46	62.32±0.98	0.000*	50.41±2.25	51.66±1.54	0.067
D50%	72.37±0.43	75.46±0.63	0.000*	66.48±1.68	69.5±1.45	0.000*	56.29±4.04	58.04±3.13	0.167

Table 2. Radical IMRT treatment plan dosimetric data comparison for OARs (± shows Standard Deviation, * shows statically significant values)

Parameter	MC	PB	P Value
PRV Spine	40.51±1.68	43.87±1.84	0.000*
Right Parotid Mean dose	24.68±3.07	26.64±3.66	0.101
Right Parotid (50% volume dose)	20.14±4.12	21.32±4.90	0.450
Left Parotid Mean dos	25.41±3.57	27.42±4.05	0.135
Left Parotid (50 % volume dose)	20.89±4.48	22.26±5.27	0.421
Brain Stem	36.94±6.79	39.08±7.38	0.384

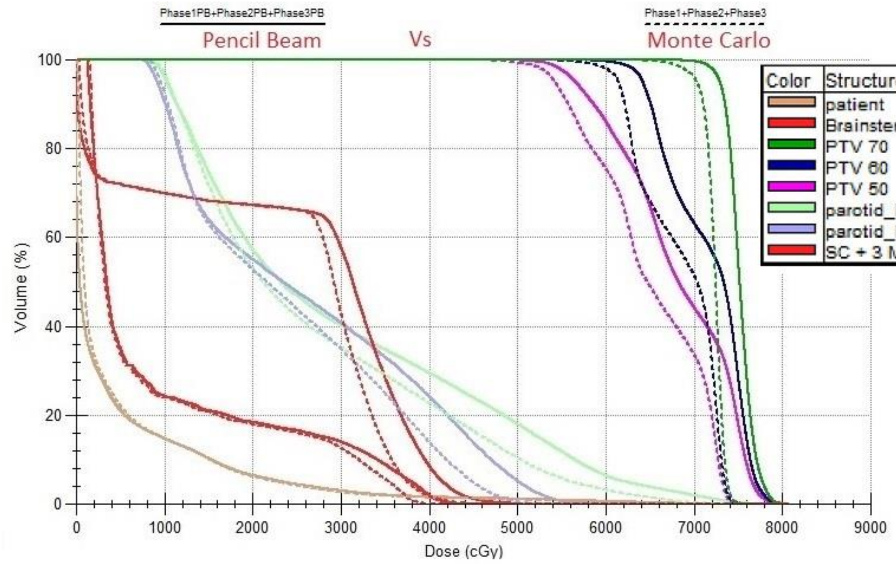

Figure 2. Comparison of Radical IMRT treatment plan DVH for MC and PB algorithms

Table 3. Adjuvant IMRT treatment plan dosimetric data comparison for PTV (± shows Standard Deviation, * shows statically significant values)

Parameter	PTV 60			PTV 50		
	MC	PB	P Value	MC	PB	P Value
Mean Dose	61.45±0.33	64.44±0.60	0.000*	54.62±0.94	57.15±0.73	0.000*
Conformity Index	0.9750±0.0124	0.993±0.0045	0.001*	0.990±0.0081	0.997±0.0026	0.028*
Homogeneity Index	1.129±0.02812	0.982±0.0092	0.000*	1.246±0.0294	1.269±0.0394	0.156
D2%	63.45±0.38	67.59±0.98	0.000*	60.98±0.91	64.41±0.92	0.000*
D98%	56.39±1.38	59.39±1.07	0.000*	48.96±1.08	50.78±1.23	0.002*
D50%	61.77±0.29	64.62±0.59	0.000*	54.34±1.16	56.83±0.89	0.000*

Table 4. Adjuvant IMRT treatment plan dosimetric data comparison for OARs (± shows Standard Deviation, * shows statically significant values)

Parameter	MC	PB	P Value
PRV Spine	40.84±1.86	44.00±1.66	0.001*
Contralateral Parotid Mean dose	26.38±2.35	28.40±2.23	0.064
Contralateral Parotid (50% volume dose)	24.45±3.14	26.29±3.40	0.225
Brain Stem	38.08±5.16	41.35±7.45	0.268

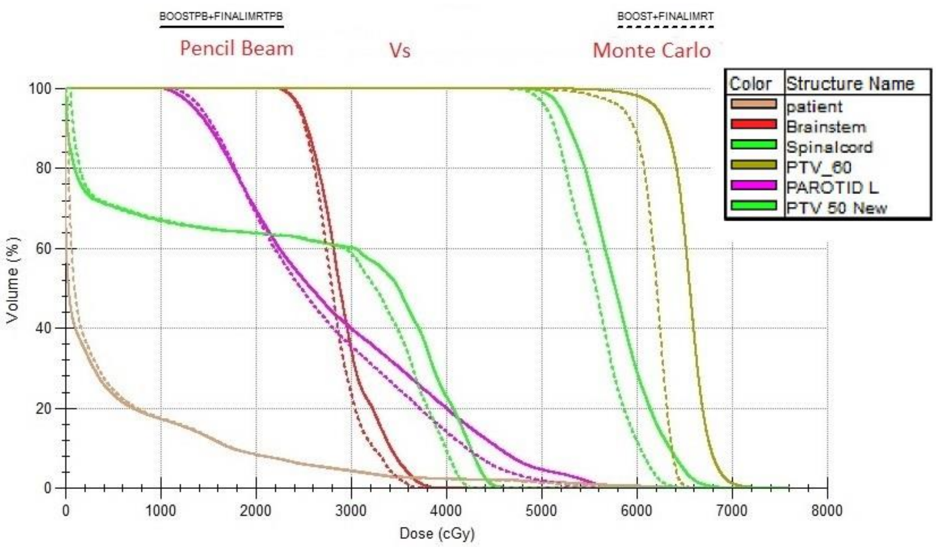

Figure 3. Comparison of Adjuvant IMRT treatment plan DVH for MC and PB algorithms

Table 5. Adjuvant 3DCRT treatment plan dosimetric data comparison for PTV (± shows Standard Deviation, * shows statically significant values)

Parameter	PTV 60						PTV 50					
	CC	MC	P Value	CC	PB	P Value	CC	MC	P Value	CC	PB	P Value
Mean Dose	61.15±0.48	61.45±0.97	0.363	61.15 ±0.48	60.78±0.44	0.078	55.34 ±1.87	55.48 ±1.76	0.859	55.34±1.87	55.02 ±1.85	0.687
Conformity Index	0.9638±0.0134	0.9635±0.0167	0.967	0.9638±0.0134	0.9600±0.0214	0.625	.9749 ±.0233	.9754 ±.0223	0.959	0.9749±.0233	0.9745±.0294	0.976
Homogeneity Index	1.1425±0.0286	1.1595±0.0268	0.167	1.1425±0.0286	1.1631±0.0756	0.409	1.3042±.0577	1.3217±.0650	0.511	1.3042±.0577	1.3008±.0656	0.900
D2%	63.57±0.66	64.76±1.00	0.040	63.57 ±0.66	63.68±1.09	0.765	62.17 ±.755	62.84 ±1.21	0.133	62.17±.755	62.19 ±.92	0.948
D98%	55.66±1.03	55.87±1.10	0.646	55.66 ±1.03	54.93±2.97	0.449	47.75 ±2.21	47.64 ±2.32	0.909	47.75±2.21	47.90 ±2.15	0.875
D50%	61.52±0.54	61.73±1.06	0.556	61.52 ±0.54	61.11±0.51	0.083	55.10 ±2.55	55.18 ±2.42	0.934	55.10±2.55	54.66 ±2.81	0.705

Table 6. Adjuvant 3DCRT treatment plan dosimetric data comparison for OARs (±shows Standard Deviation, * shows statically significant values)

Parameter	CC	MC	P Value	CC	PB	P Value
PRV Spine	28.41±11.41	24.42±12.53	0.444	28.41±11.41	24.79±13.84	0.510
Contralateral Parotid Mean dose	5.29±2.07	5.11±2.05	0.843	5.29±2.07	4.20±2.05	0.232
Contralateral Parotid (50% volume dose)	5.24±2.05	5.06±2.03	0.839	5.24±2.05	4.16±2.03	0.227
Brain Stem	11.47±4.11	9.38±2.83	0.180	11.47±4.11	7.92±2.86	0.029

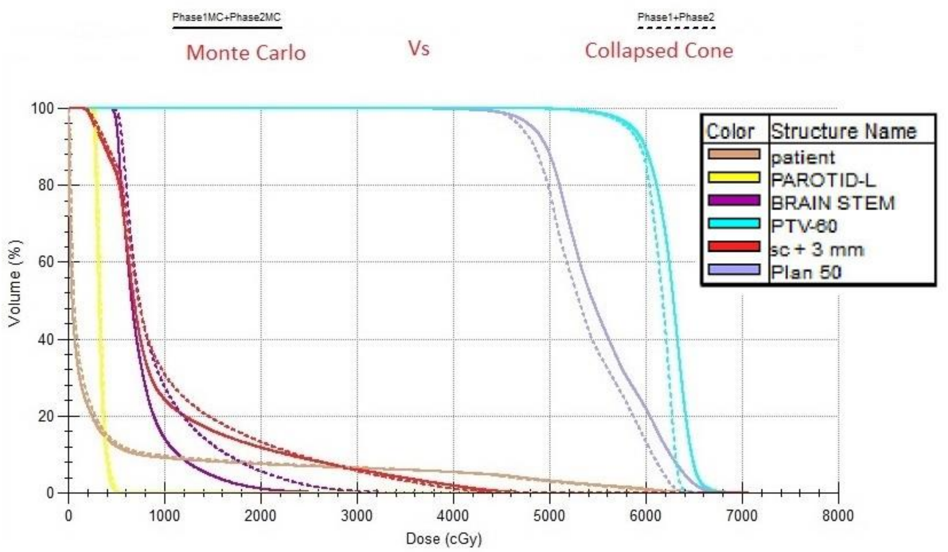

Figure 4. Comparison of Adjuvant 3DCRT treatment plan DVH for CC and MC algorithms

Adjuvant 3DCRT-OAR'S

A comparison between CCS with MC and CCS with PB algorithms for adjuvant 3DCRT treatment plan OARs dose was tabulated in Table 6. Critical structure statistical analysis showed there was no statistically significant p-value found for PRV spine, Contralateral parotid mean dose, Contralateral parotid 50 % dose, and brain stem (p-value = 0.444, 0.843, 0.839, and 0.180) between the CCS and MC algorithms. Similarly, for CCS with PB algorithms results, no statistically significant p-value found for PRV spine, contralateral parotid mean dose, and contralateral parotid 50 % dose (p-value = 0.510, 0.232,and 0.227), except brain stem p-value 0.029. Figure 5 shows the comparison of adjuvant 3DCRT treatment plan DVH for CCS and PB algorithms.

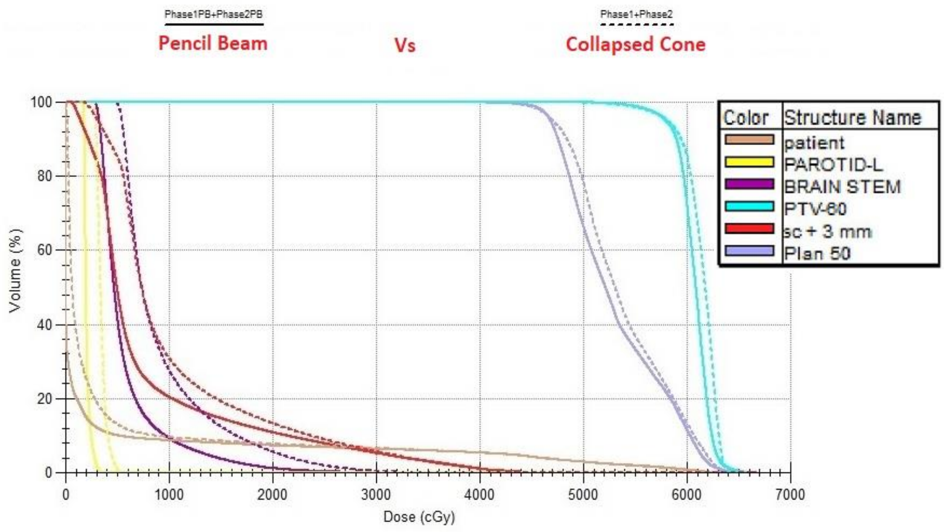

Figure 5. Comparison of Adjuvant 3DCRT treatment plan DVH for CC and PB algorithms

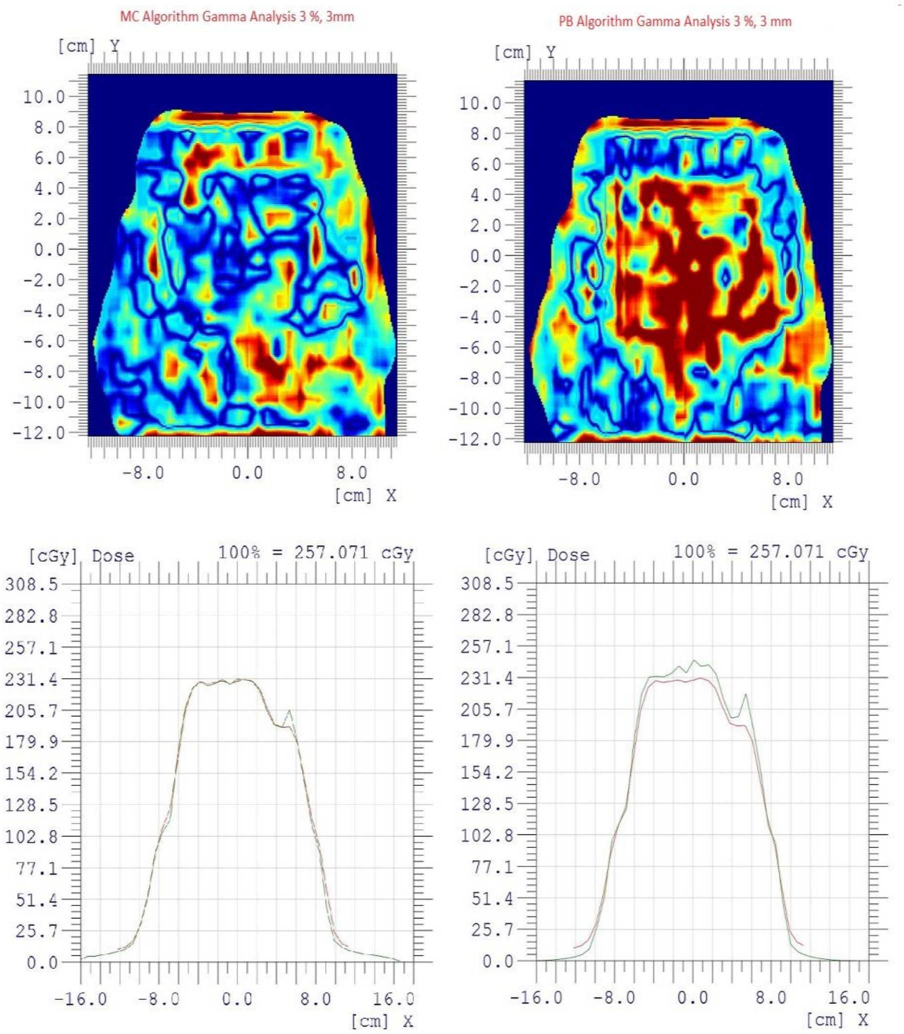

Figure 6. Comparison of gamma passing rate between MC and PB algorithms using gamma index (3%, 3 mm) criteria. MC algorithm gamma analysis result shows that there is good agreement between planned and delivered. PB algorithm treatment plan shows the miss match between the planned and delivered.

IMRT Patients Specific QA

IMRT patient-specific QA for MC and PB algorithmsand gamma index results were tabulated in table 7. Gamma index (3%, 3mm) results showthat the MC treatment plan was acceptable for treatment delivery and the gamma pass rate was more than 95% for all the patients. The PB treatment plan algorithm gamma analyses results were found to be not within the acceptable values. The gamma index values between MC and PB algorithms showed that statistically significant difference ($p < 0.000$) Figure 6 shows the comparison of gamma index (3%, 3 mm) criteria between MC and PB algorithms.

Table 7. IMRT Quality assurance comparison between MC and PB algorithms (± shows Standard Deviation, * shows statically significant values)

Parameter	Gamma Passing Rate 3%, 3mm		P Value
	MC	PB	
Radical RT patients	97.47±1.03	91.16±3.06	0.000*
Adjuvant RT Patients	97.79±1.30	91.25±2.45	0.000*

Discussion

This study compared different dose calculation algorithms for IMRT and 3DCRT techniques in H&N cancer patients. The first group of patients was treated by radical treatment with IMRT techniques. The results showed that all the target volume parameters such, as mean dose, CI, $D_{2\%}$, $D_{98\%}$, and $D_{50\%}$showed a significant difference between MC and PB algorithms. Similarly, the second group of patients were also treated with the IMRT technique for adjuvant treatment, and the results were similar to the radical treatment patients. The OAR doses for both radical and adjuvant group of patients shows show the serial organ spinal cord showing the significant differences are present in both the groups. Results from Kathirvel et al concluded that Monaco™ TPS was superior in serial organ sparing and the eclipse planning system was superior in parallel organ sparing [9].

The statistical analysis results showed that the mean dose and 50% dose of parallel organs such as,parotid didn't show any statically significant differences. But when comparing the mean dose of parallel organs, there is a difference of 2Gy between MC and PB algorithms. Gamma index (3%, 3mm) result indicates the MC treatment plan was acceptable for treatment delivery. The gamma analysis of PB treatment plan algorithm was not found within the acceptable limit and hence not suitable for treatment delivery. The isodose distribution shows that PB dose coverage is higher when compared with MC algorithm in both IMRT groups of patients. Compared to the MC algorithm, in both IMRT treatment group plans, PB algorithm over estimates the dose to the tumor and other normal structures, as clearly depicted in tables 1 to 4.Zhao et al studied the MC algorithm with CCS and PB algorithms for treating lung tumor and concluded that CCS algorithms overestimated the dose in the IMRT treatment plan, but in the 3DCRT treatment plan, it was within the acceptable limits. PB algorithm overestimate the dose to the target for both 3DCRT and IMRT treatment plan [23].Using these results the MC algorithms are proved that, for small segment dose calculation the MC algorithm gives the accurate results.

The third group of patients were treated with adjuvant treatment by3DCRT techniques for which all the target volume parameters such as mean dose, CI, HI, $D_{2\%}$, $D_{98\%}$ and $D_{50\%}$shows no significant differences between CCS, MC, and PB algorithms. The isodose distribution shows that coverage was almost similar for MC and PB algorithms in comparison to CCS algorithmin the 3DCRT treatment plans. The OAR dose result shows no statistically significant p-value found between the CCS, MC and PB algorithms in the 3DCRT treatment plan. Table 5 & Table 6 show that recalculated MC and PB algorithms dose were very close to the originally calculated CCS algorithm in the 3DCRT treatment plan.

The treatment plan accuracy is based on the algorithms used for the treatment dose calculation. IMRT treatment plan is generated with multiple numbers of small segments in the treatment delivery. For small segment dose calculation, a more precise dose calculation algorithm is necessary. The present study clearly demonstrates that, IMRT treatment plan generation, which is head and neck in the treatment area, needs a more accurate dose calculation algorithm like the MC which is the gold standard algorithm. In 3DCRT the treatment plan, each segment usually has a large area opening volume and in such open field dose calculation MC, CCS and PB algorithm doses were close to each other.

Many studies have been conducted on dose calculation accuracy based on algorithms in the inhomogeneous treatment area [24-29]. It was concluded by Ali I & Ahmad S that the discrepancy between PB and MC is more for 15 MV when compared to 6 MV. The point dose measured may mislead the QA for assessing the dose calculation algorithms. The clinical QA verification of algorithms requires at least 2 or3 dimensions measurement QA instrument for accurate verification of algorithms instead of point dose measurements with heterogeneous phantoms [30].The vanderstraeten et al stated that the lung dose calculation accuracy depends on the performance of the calculating algorithm in the area of electronic disequilibrium which, arises due to tissue inhomogeneities causing more variation in the densities [31].The kry et al study concluded that MC algorithms dose calculation gives good agreement; the dose estimation was within 0.6% [32].The MC algorithm's performance was better and more accurate for dose distribution in heterogeneous patient treatment planning.

Conclusion

For the IMRT treatment plan, there was a significant difference shown between the MC and PB algorithms for the PTV, and there is no statistical difference for OAR dose except for PRV spine. In the IMRT treatment plan PB algorithm overestimated the dose, because there are more numbers of small segments in the treatment plan. The 3DCRT treatment plans did not show a statistically significant difference between the MC, PB, and CCS algorithms.

The treatment plan accuracy is based on the algorithms used for the treatment dose calculation. IMRT treatment plans are generated with multiple numbers of small segments in the treatment delivery. For small segment dose calculation, there is always a need for more precise dose calculation algorithm. The Present study demonstrates that IMRT treatment plan generation in the head and neck treatment area needs more accurate dose calculation algorithm like the Monte Carlo gold standard algorithm. For 3DCRT treatment planning, each segment uses a large area treating volume for dose calculation. In the open field dose calculation, MC, CCS, and PB all three algorithms are calculated, doses were close to each other and no algorithm was superior to the other in 3DCRT dose calculations .This study discusses the precision of different dose calculation algorithms and shows which algorithm is more suitable for head & neck radiotherapy.

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