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Impact of Different Grid Sizes and Different Dose Calculation Algorithms on Dosimetric Parameters for Head and Neck IMRT.

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Purpose: the aim of this work is to study the dosimetric impact of grid size and dose calculation algorithm on intensity modulated radiotherapy (IMRT) plans for head and neck (H&N) cancer cases. **Method**: IMRT plans were generated in the MONACO® treatment planning system (TPS) which supports calculations using different calculation algorithms, Monte Carlo (MC) and pencil beam (PB). Retrospective plans were generated for eleven patients who already been treated for H&N cancer. 11 patient's plans were retrieved and recalculated by changing between grid size (2, 3, 4, 5 mm) and algorithm (MC and PB) for each plan. ICRU dosimetric parameters criteria are used to evaluate the different plans in this study. For planning target volume (PTV) criteria used are minimum, maximum and mean doses, $D_{5\%}$, $V_{95\%}$, homogeneity index (HI), conformity index (CI) and gradient index (GI). And for organs at risk (OARs) maximum dose (Dmax), mean dose (Dmean) values were evaluated. However, for the volume of the whole body (WB) receiving 2 Gy (V_{2Gy}) and 5 Gy (V_{5Gy}) were assessed. **Results:** All plans for patients were analyzed. Regarding HI and CI, MC plans show better results than PB plans. At 3mm grid, HI was 0.24 ٠,٠٨± for MC and 0.26 ٠,٠7± for PB with P-value <0.05. At 5mm grid, CI was 0.93 ٠,٠4± for MC and 0.95 ٠,٠4± for PB with P-value <0.05. Comparing algorithms at the same grid size shows significance (P-value < 0.05) in all PTV parameters (except Dmin and mGI). Comparing grid sizes at the same algorithm show significance in only Dmax, Dmean, $D_{5\%}$, $V_{95\%}$ and CI_2. At 2mm grid size Dmax was 74.26 ±4.47 for MC and 76.34 ± 5.03 for PB, Dmean was 62.88 ±2.02 for MC and 63.82 ± 2.28 for PB, $D_{5\%}$ was 68.55 ±4.20 for MC and 70.20 ± 4.40 for PB**,** $V_{95\%}$ was 95.79 ±1.09 for MC and 96.90 ± 0.70 for PB and CI_2 was 0.94 ±0.05 for MC and 0.95 ± 0.04 for PB**.**

Introduction

Malignant tumors are the second leading cause of death globally. According to the latest worldwide statistics there were an estimated 19.3 million new cases. About 5% of all cases were diagnosed with H&N cancer type (562,328 cases). Around 50% of them dead from cancer (277,597 deaths) of H&N [1].In 2023, in the United States estimated about 66,920 cases will be diagnosed with H&N cancer and 15,400 deaths [2]. H&N cancer is a malignant tumor appears in or around the throat, larynx, nasal cavity, sinuses, and oral cavity. It doesn't include all tumors that exist in the H&N area like brain, eyes, thyroid and esophagus [2]. To treat H&N cancer, a single or a mixed therapy may be required. That includes surgery, radiotherapy (RT) or medications (chemotherapy, targeted therapy or immunotherapy). Radiotherapy becomes mainly important in H&N cancer treatment. It is applied before, during, or after surgery using high doses of ionizing radiation to the target volume [2]. The purpose of RT is to deliver sufficient doses to target volume, aiming to reduce recurrence probability and control the spread of tumor to normal tissues. Achieve that using advanced techniques with high accuracy and precise dose delivery which includes 3DCRT, IMRT or VMAT. IMRT and VMAT techniques are advanced forms of conformal radiotherapy which use many segments in each field or arc that give the ability to deliver conformal radiation doses to malignant tumor and spare the surrounding organs from high dose. To achieve that TPS uses different dose calculation algorithms like MC, PB, AAA, and Collapsed cone. Algorithms are responsible for the correct representation of doses in patient. Another

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important parameter in TPS dose calculation is the dose calculation grid. Grid or voxel size represent a pixel connecting two adjacent slices (where pixel is a picture element). Grid size is important to define the resolution of dose distribution and determine the volume of contour for the target and OARs. A large voxel size (such as 5 mm) results in a lesser number of voxels in the calculation volume and, therefore, a shorter computing time. But compared to smaller voxels, 5 mm are less accurate [3, 4]. From that changing in grid size affects the resolution of dose distribution in target volume and OARs, that would change the DVHs in a treatment plan. This is important in the treatment plan quality assurance because dose-volume, and radiobiological parameters are calculated based on the DVHs of target volume and OARs. Subsequently, grid size variation may impact plan evaluation process [4].

Several authors, Shiv P. Srivastava et al. [3] evaluated the dosimetric and radiobiological impact of calculation grid size on head and neck IMRT. Kyeong- Hyeon Kim et al. [5] compared different algorithms and different grid size using the dosimetric and radiobiological parameters of prostate volumetric modulated arc therapy (VMAT) plans. Yelda Elcim et al. [6] evaluated dosimetric parameters for calculated dose differences between the PB and MC algorithms in a highly heterogeneous medium for lung phantom. Tingting Cao et al. [7] analyzed different evaluation indexes for prostate stereotactic body radiation therapy plans: conformity index, homogeneity index and gradient index. Burela et al. [8] studied the volumetric and dosimetric for adaptive IMRT locally advanced H&N cancer. In 2022 Nikolett Buciuman and Loredana G Marcu [9] studied the dosimetric differences between IMRT and VMAT for H&N cancer for sequential boost (Seq-boost) and simultaneous integrated boost techniques (SIB). In 2022 Duong Thanh Tai et al. [10] studied the Dosimetric and radiobiological comparison in head-and-neck radiotherapy using JO-IMRT and 3D-CRT. The dosimetric impact on IMRT plans when using Monte Carlo and Pencil Beam dose calculation algorithms with different grid sizes was investigated in this study.

Materials and Methods

Treatment plans

The IMRT treatment plans for 11 H&N cancer cases (tumor site is between nasopharynx and tongue). Patients were selected randomly, The PTV volume varied in the range of 259.0 to 848.9 cc. The CT images were acquired with slice thickness of 3 mm on light speed® GE® CT simulator. IMRT

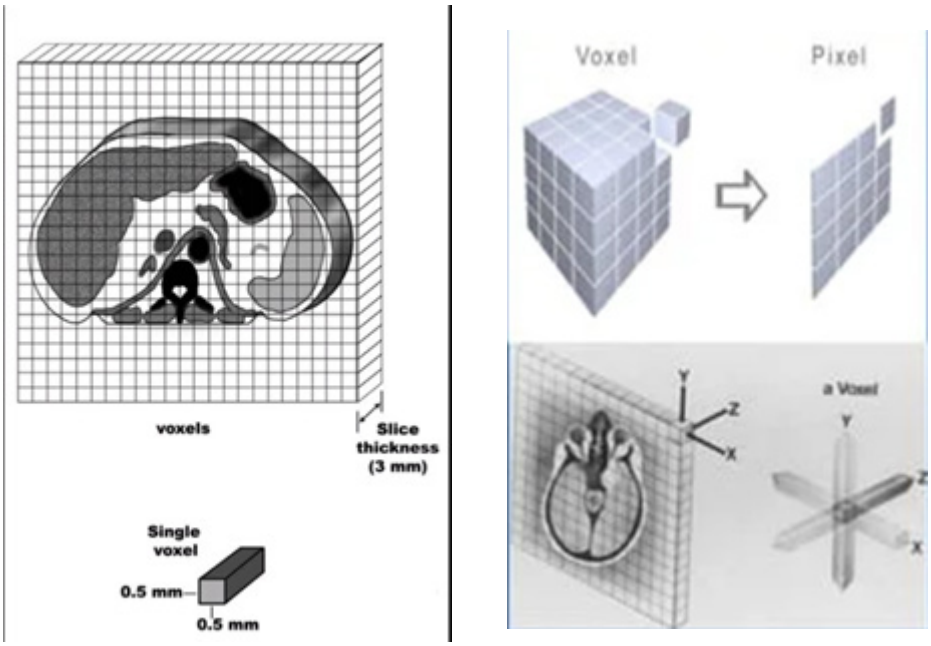

Fig. 1 represent the grid or voxel size.

plans were created using MONACO 5.1®TPS, using 9 fields started from Gantry 180° and rotate equally spaced around patient using SYNERGY ELEKTA® linear accelerator. Step and shoot IMRT delivery technique was used to deliver 60 Gy at 30 fractions to PTV (2 Gy / f). The plans were optimized to achieve covering at least 95% of target volume with 95% of prescribed dose. Monaco® uses two different calculation algorithms PB and MC. The Monte Carlo (MC) method is used in many commercial systems because it achieves the highest accuracy in radiotherapy dose calculation [11]. In general, TPSs used a range of grid sizes from 1 to 10 mm for dose calculation. In MONACO® The most used grid sizes in the range 2.5 - 5.0 mm as compromise between computational time and dose calculation accuracy. In this study, 2, 3, 4, 5 mm grid sizes were used and calculated plans using each algorithm separately. This results in having eight plans generated for each patient enrolled in this study. Dose-volume constraints of PTV and OARs used in inverse planning IMRT are outlined in table1.

Plan evaluation

The mainly tool used is dose-volume histogram (DVH) which generated for each plan to get volume and dose parameters for the PTV and for OARs.

TABLE 1. Dose constraints for IMRT plan [12, 13, 14].

Structure	Dose Constraints
Spinal cord (1cc)	Dmax< 45 Gy
Brainstem (1cc)	Dmax< 54 Gy
Optic chiasm	Dmax< 54 Gy
Optic nerve	Dmax < 54 Gy
Parotid glands	Dmean < 26 Gy
Larynx	Dmean< 40 gy
PTV	Dmax< 120 % of PD Dmean< 105 % $D_{5\%}$< 105 % $V_{95\%}$> 95%

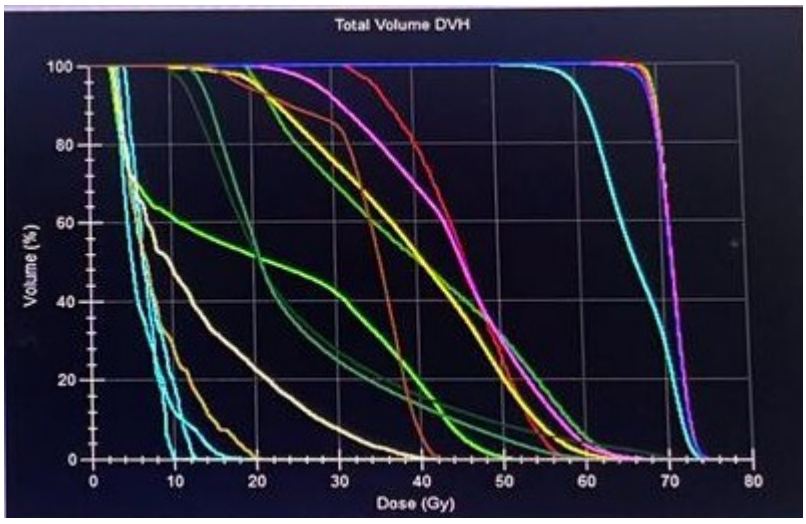

Fig. 2. represent the DVH for PTV and OARs.

OAR parameters

Dosimetric parameters (for most common OARs in H&N area) include Dmean for parotid glands, larynx, eye and cochlea. Dmax for brainstem, spinal cord, mandible and optical structures.

PTV parameters

Include Dmean, Dmax, V95% (volume irradiated by 95% of prescribed dose) represent the target coverage and hot spot D5% (representing the dose received to volume 5% of PTV) Homogeneity index (HI), conformity index (CI), conformation number (CN) and gradient index (GI) were calculated. Each index was calculated by 2 equations which are the most commonly used for calculations. HI defined by equations (1 &2)

$$HI_1 = \frac{D_{2\%} - D_{98\%}}{D_{50\%}} \quad (1)$$

The preferred values are that approaching to zero, which indicates the most homogenous treatment plans. The ideal value for IMRT is 0.1 [15].

Another formula is defined by [16]:

$$HI_2 = \frac{D_{2\%} - D_{98\%}}{PD} \quad (2)$$

D2%, D98% and D50% represent the doses cover volume 2%, 98% and 50% of PTV and PD is the prescribed dose for PTV. CI equations are [17]:

$$CI_1 = \frac{PTV_{RI}}{PIV} \quad (3)$$

$$CI_2 = \frac{PTV_{RI}}{PTV} \quad (4)$$

PTVRI and PIV are target, and whole body WB volume covered by reference isodose. CN defined by equation [18]:

$$CN = CI_1 \times CI_2 \quad (5)$$

This equation represents the quality of target coverage taking into account the normal tissues volume sparing and coverage of target volume. The ideal value of CI is 1 that means100% of PD is delivered to the PTV, and no dose was delivered to any adjacent tissue. For IMRT the ideal value is 0.7. Higher values mean poor dose conformity to the PTV.

Gradient index which means the dose fall-off steepness outside the PTV. Described by equation [17]:

$$GI = \frac{V_{50\%}}{V_{100\%}} \quad (6)$$

Other formula is modified the GI to take into account the degree of dose conformity, described by equation:

$$mGI = \frac{V_{50\%}}{V_{100\%}} \times \frac{PIV_{RI}}{PTV} \quad (7)$$

The lower GI value means steeper gradient of dose distribution outside PTV, and better normal tissue sparing.

Statistical analysis:

The statistical analysis was carried out using two-way ANOVA using SPSS®25(IBM Corp. Released 2013). Data were treated as a complete randomization design according to Steel et al. (1997). Multiple comparisons were carried out applying Duncun test. The significance level was set at < 0.05.

Results and Discussion

Dosimetric evaluation was performed for 11 patients with totally 88 plans were generated using MONACO® TPS. Data of P-values are listed in Table 2.

PTV60 parameters

Values of mean and standard deviation of dosimetric parameters for PTV60 are listed in table 3 with impact of dose calculation grid sizes and algorithms. Table 3 shows significance for changing grid sizes at the same algorithm for Dmax, Dmean, and $V_{95\%}$. Significance appears also when changing algorithms at the same grid size for all PTV parameters except mGI and Dmin. At 2mm grid size, $V_{95\%}$ with the MC algorithm was 95.79%, and with PB was 96.9% (p- value >0.05). Whereas at 5 mm grid size, $V_{95\%}$ with the MC algorithm was 94.84%, and with PB was 96.58% (p- value < 0.05). $V_{95\%}$ decreases with increasing grid size as shown in fig 4 with higher values in PB than MC. The same behavior for Dmean (as seen in fig 5), Dmax and $D_{5\%}$. Contrary to this behavior for Dmin which increased with increasing grid size.

TABLE 2. Means of P-values for PTV and OARs.

Structure	p-value		Structure	p-value	
PTV	Algorithm	Grid size	OAR	Algorithm	Grid size
Dmin	0.1	0.5	V_{2GY}(WB)	<0.05	0.1
Dmax	<0.05	<0.05	V_{5GY}(WB)	0.02	0.1
Dmean	<0.05	<0.05	Brainstem	<0.05	0.1
$D_{5\%}$	<0.05	<0.05	Spinal cord	<0.05	0.2
$V_{95\%}$	<0.05	<0.05	Mandible	<0.05	<0.05
HI_1	<0.05	0.2	Lens RT	<0.05	<0.05
HI_2	<0.05	0.2	Lens LT	0.1	<0.05
CI_1	<0.05	0.3	Chiasm	0.07	0.05
CI_2	<0.05	<0.05	Optic Nerve RT	0.2	0.5
CN	<0.05	0.6	Optic nerve LT	<0.05	0.7
GI	<0.05	0.2	Parotid gland RT	0.08	<0.05
mGI	0.6	0.9	Parotid gland LT	0.6	<0.05
			Cochlea	<0.05	<0.05
			Larynx	<0.05	0.2
			Eye RT	0.12	0.16
			Eye LT	0.05	0.2

TABLE 3. Mean and standard deviation of dosimetric parameters for PTV.

PTV parameters	Monte Carlo				Pencil Beam			
	2 mm	3 mm	4 mm	5 mm	2 mm	3 mm	4 mm	5 mm
Dmin	32.30 ±9.87^{B}	32.05 ±8.59^{B}	32.71 ±9.57^{AB}	34.02 ±8.96^{A}	32.17 ±9.55^{A}	31.28 ±9.61^{A}	32.72 ±10.05^{A}	31.26 ±11.10^{A}
Dmax	74.26 ±4.47^{A}	73.76 ±4.98^{A}	72.91 ±4.43^{B}	72.45 ±4.69^{B}	76.34 ±5.03^{A}	75.69 ±4.50^{B}	75.07 ±4.52^{C}	75.37 ±5.04^{BC}
Dmean	62.88 ±2.02^{A}	62.77 ±2.02^{AB}	62.65 ±1.96^{AB}	62.50 ±1.97^{B}	63.82 ±2.28^{A}	63.67 ±2.28^{A}	63.24 ±1.89^{B}	63.39 ±2.22^{B}
$_{D5}$%	68.55 ±4.20^{A}	68.41 ±4.26^{A}	67.80 ±3.98^{A}	68.50 ±4.03^{A}	70.20 ±4.40^{A}	69.93 ±4.40^{AB}	69.73 ±4.37^{BC}	69.48 ±4.37^{C}
$V_{95\%}$	95.79 ±1.09^{A}	95.56 ±1.12^{B}	95.29 ±1.19^{C}	94.84 ±0.99^{D}	96.90 ±0.70^{A}	96.82 ±0.72^{A}	96.83 ±0.66^{A}	96.58 ±0.62^{B}

A, B & C: There is no significant difference (P>0.05) between any two means for the same parameter, within the same row have the same superscript letter.

Dosimetric parameters for PTV:

Mean and standard deviation values of HI, CI , CN and GI are listed in table 4. Changing algorithms at the same grid size shows significance in HI, CI, CN and GI. Changing grid sizes at the same algorithm shows significance only with CI_2. The HI values with MC is lower than PB which close to the ideal value. According to CN, the MC display values closer to 1 than that of PB. As observed from fig. 3 GI increased with increasing grid size (lower values are preferred). The lowest value was 1.24. which resulted with PB at 2 mm grid size. mGI shows no significance when changing grid sizes or algorithms.

TABLE 4. Mean and standard deviation of HI, CI, CN and GI.

PTV parameters	Monte Carlo				Pencil Beam			
	2 mm	3 mm	4 mm	5 mm	2 mm	3 mm	4 mm	5 mm
HI_1	0.23 ±0.07^{A}	0.23 ±0.07^{A}	0.23 ±0.07^{A}	0.24 ±0.06^{A}	0.25 ±0.06^{A}	0.25 ±0.06^{A}	0.24 ±0.06^{A}	0.24 ±0.06^{A}
HI_2	0.25 ±0.07^{AB}	0.24 ±0.08^{B}	0.24 ±0.07^{B}	0.26 ±0.07^{A}	0.27 ±0.07^{A}	0.26 ±0.07^{A}	0.26 ±0.07^{A}	0.26 ±0.07^{A}
Cl_1	0.75 ±0.10^{A}	0.76 ±0.10^{A}	0.76 ±0.10^{A}	0.76 ±0.10^{A}	0.69 ±0.07^{A}	0.70 ±0.07^{A}	0.71 ±0.07^{A}	0.71 ±0.07^{A}
Cl_2	0.94 ±0.05^{A}	0.94 ±0.05^{A}	0.94 ±0.05^{A}	0.93 ±0.04^{B}	0.95 ±0.04^{A}	0.95 ±0.05^{A}	0.95 ±0.04^{A}	0.95 ±0.04^{A}
CN	0.71 ±0.10^{A}	0.71 ±0.10^{A}	0.71 ±0.10^{A}	0.71 ±0.10^{A}	0.66 ±0.07^{B}	0.67 ±0.07^{AB}	0.67 ±0.07^{AB}	0.68 ±0.07^{A}
Gl	1.33 ±0.34^{A}	1.35 ±0.38^{A}	1.38 ±0.37^{A}	1.39 ±0.41^{A}	1.24 ±0.24^{A}	1.25 ±0.26^{A}	1.25 ±0.25^{A}	1.27 ±0.26^{A}
mGl	1.69 ±0.38^{A}	1.69 ±0.41^{A}	1.72 ±0.39^{A}	1.73 ±0.42^{A}	1.70 ±0.27^{A}	1.70 ±0.28^{A}	1.69 ±0.27^{A}	1.70 ±0.28^{A}

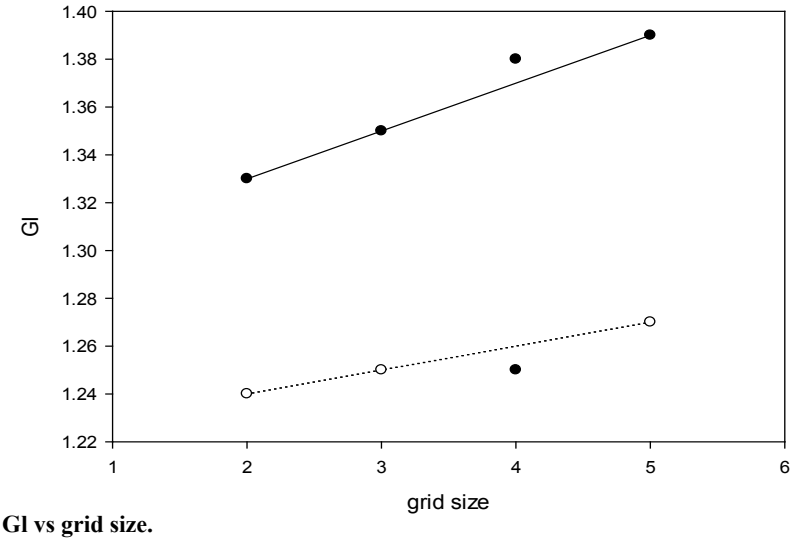

Fig. 3. represent Gl vs grid size.

3.2 OARs

For OARs significance appears when changing grid size at the same algorithm for mandible, lens, parotid glands and cochlea ,Also significance appears in changing algorithms at the same grid size in most OARs as seen in table 2. Values of mean and standard deviation of dosimetric parameters for OARs are listed in table 5. As shown in table 5 PB has been estimated higher doses than MC in all OARs except lens, larynx and parotid glands. For V_{2Gy} and V_{5Gy} (WB) as seen in table 5, no significance in changing between grid sizes. Significance appears in changing between algorithms. Dmax of right lens RT at 2 mm grid size was 7.05 Gy, and at 5 mm was 7.61Gy (P-value < 0.05) these values for MC. Whereas for PB at 2 mm grid size was 6.94 Gy, and at 5 mm was 7.40 Gy (P-value < 0.05). Dmean of right parotid gland RT at 2 mm grid size was 25.37 Gy, and at 5 mm was 25.84 Gy (P-value < 0.05) these values for MC. Whereas for PB at 2 mm grid size was 25.38 Gy, and at 5 mm was 25.77 Gy (P-value < 0.05).

TABLE 5. mean and standard deviation of dosimetric parameters for OARs.

OAR	Monte Carlo				Pencil Beam			
	2 mm	3 mm	4 mm	5 mm	2 mm	3 mm	4 mm	5 mm
$V_{2\,GY}$(WB)	44.37 ±15.44^{B}	44.31 ±15.35^{B}	43.89 ±15.40^{B}	46.89 ±13.82^{A}	43.12 ±15.09^{A}	42.98 ±14.90^{A}	43.22 ±15.18^{A}	43.44 ±15.20^{A}
$V_{5\,GY}$(WB)	34.41 ±11.59^{B}	34.38 ±11.52^{B}	33.97 ±11.53^{B}	36.48 ±10.16^{A}	33.65 ±11.26^{A}	33.56 ±11.13^{A}	33.73 ±11.34^{A}	33.91 ±11.35^{A}
Brainstem	43.99 ±9.78^{A}	44.02 ±9.50^{A}	43.68 ±9.57^{A}	43.52 ±9.61^{A}	45.17 ±10.35^{A}	44.95 ±10.20^{A}	43.85 ±9.67^{B}	44.73 ±10.32^{A}
Spinal cord	37.09 ±4.56^{A}	37.05 ±4.34^{A}	37.11 ±4.24^{A}	37.29 ±4.33^{A}	38.12 ±4.51^{A}	38.04 ±4.36^{A}	37.42 ±3.94^{B}	38.21 ±4.32^{A}
Chiasm	37.87 ±16.22^{A}	37.52 ±16.01^{AB}	37.40 ±15.71^{AB}	37.11 ±15.73^{B}	38.56 ±15.94^{A}	38.22 ±15.73^{AB}	37.25 ±15.4^{C}	37.68 ±15.68^{BC}
Optic nerve RT	37.86 ±16.73^{A}	37.36 ±16.27^{A}	37.11 ±16.46^{A}	37.17 ±16.05^{A}	37.76 ±16.85^{B}	37.43 ±16.75^{B}	40.20 ±14.36^{A}	37.33 ±16.57^{B}
Optic nerve LT	39.20 ±15.28^{A}	38.88 ±15.37^{AB}	38.37 ±15.02^{B}	39.09 ±14.94^{A}	39.64 ±15.49^{A}	39.32 ±15.35^{A}	39.82 ±14.88^{A}	39.29 ±15.10^{A}
Lens RT	7.05 ±3.21^{C}	7.11 ±3.22^{C}	7.41 ±3.21^{B}	7.61 ±3.47^{A}	6.94 ±2.85^{B}	6.91 ±2.90^{B}	7.32 ±2.74^{A}	7.40 ±3.14^{A}
Lens LT	5.79 ±2.24^{C}	6.16 ±2.41^{B}	6.15 ±2.56^{B}	6.59 ±2.85^{A}	5.85 ±2.06^{B}	5.92 ±2.17^{B}	6.20 ±2.05^{A}	6.27 ±2.38^{A}
Mandible	67.09 ±1.40^{A}	66.61 ±0.92^{B}	65.82 ±1.19^{C}	65.61 ±1.57^{C}	69.68 ±1.86^{A}	69.27 ±1.88^{A}	68.45 ±1.80^{B}	68.28 ±1.99^{B}
Eye RT	9.49 ±5.94^{A}	9.52 ±5.96^{A}	9.68 ±6.03^{A}	9.73 ±6.02^{A}	9.66 ±5.87^{B}	9.63 ±5.87^{B}	10.29 ±5.64^{A}	9.75 ±5.89^{B}
Eye LT	41.86 ±6.84^{A}	42.15 ±6.43^{C}	42.59 ±6.48^{B}	42.75 ±6.04^{AB}	44.02 ±7.31^{AB}	43.95 ±7.06^{B}	44.25 ±6.85^{A}	44.01 ±6.84^{B}
Cochlea RT	41.86 ±6.84^{A}	42.15 ±6.43^{C}	42.59 ±6.48^{B}	42.75 ±6.04^{AB}	44.02 ±7.31^{AB}	43.95 ±7.06^{B}	44.25 ±6.85^{A}	44.01 ±6.84^{B}
Cochlea LT	43.13 ±8.33^{C}	43.38 ±7.98^{C}	43.76 ±7.72^{B}	44.24 ±7.45^{A}	45.37 ±8.63^{B}	45.32 ±8.40^{B}	46.10 ±8.22^{A}	45.51 ±7.96^{B}
Larynx	46.55 ±5.66^{A}	46.61 ±5.61^{A}	46.79 ±5.54^{A}	46.94 ±5.53^{A}	46.00 ±5.63^{B}	45.91 ±5.59^{B}	46.90 ±4.88^{A}	45.99 ±5.48^{B}
Parotid gland RT	25.37 ±6.12^{C}	25.50 ±6.11^{BC}	25.66 ±6.07^{B}	25.84 ±6.00^{A}	25.38 ±6.31^{B}	25.41 ±6.28^{B}	25.38 ±6.20^{B}	25.77 ±6.15^{A}
Parotid gland LT	26.07 ±7.13^{C}	26.14 ±7.12^{BC}	26.26 ±7.10^{B}	26.50 ±7.05^{A}	26.09 ±7.19^{B}	26.13 ±7.16^{B}	26.38 ±7.16^{A}	26.28 ±7.23^{A}

From these results it was found that 2 mm grid size gives better target coverage and better sparing to health tissues than 5 mm. This shows agreement with studies which demonstrated that the quality of the treatment plan improves with decreasing grid size [3, 5]. From that mean doses of PTV decreased with increasing grid size. Also $V_{95\%}$, $D_{5\%}$, and Dmax show the same behavior. In contrast Dmin increased with increasing grid size. Fig 4 and 5 represent the behavior of $V_{95\%}$ and mean doses of PTV respectively for different plans. For parallel OARs Dmean increased with increasing grid size. For serial OARs Dmax decreased with increasing grid size. $V_{95\%}$ was higher in PB than MC, and differences for both algorithms were statistically significant (p-value < 0.05). The PB algorithm estimated higher doses for the target than MC algorithm. These results are agreement with several studies that demonstrated that the MC has been reported to predict more accurate doses than PB [19, 20, 21, 6].

There is no change in monitor units with the change of grid size or algorithm because plans were recalculated by keeping the same dosimetric parameters and only changing the grid size.

Conclusion

From the results discussed above the recommended grid size is the smallest available one (2 or 3 mm). It was shown no significance between 2 and 3 mm at the same algorithm in all OARs (except lens) but Significance for grid sizes 4 and 5 mm. Impact of algorithm show significant in all evaluated parameters (except PTV Dmin and mGI) so the recommended algorithm is MC [19, 21].

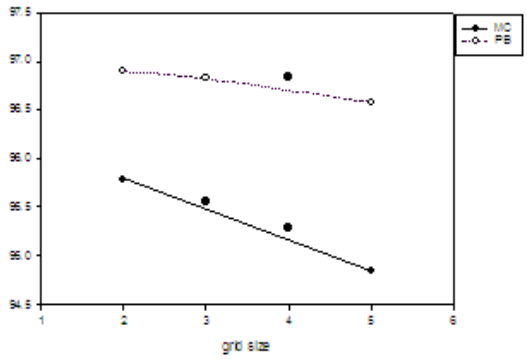

Fig. 4. represent V95% vs grid size.

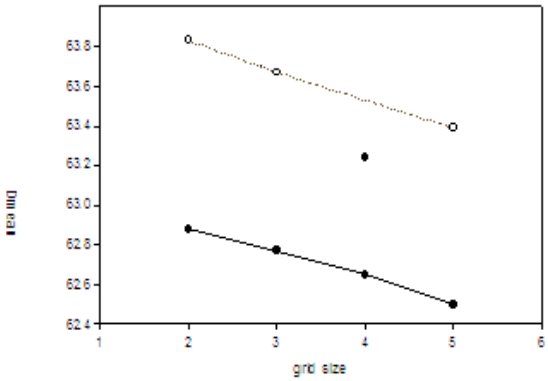

Fig. 5. represent Dmean VS grid size.

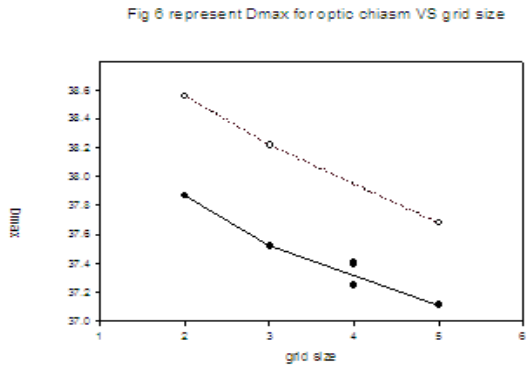

Fig. 6. represent D max for optic chiasm VS grid size.

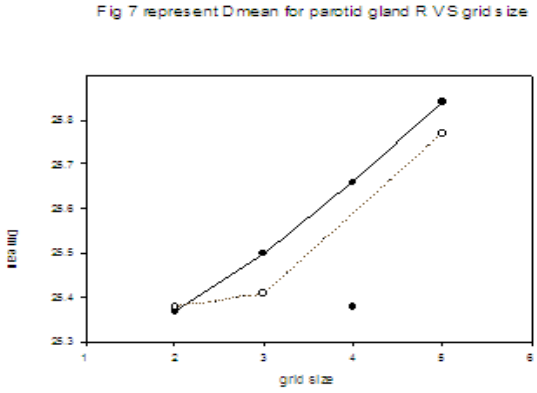

Fig. 7. represent Dmean for parotid gland R VS grid size.

References

[1] Sung, Hyuna; Ferlay, Jacques; Siegel, Rebecca L; Laversanne, Mathieu ; Soerjomataram, Isabelle ; Jemal, Ahmedin ; Bray, Freddie;, "Global Cancer Statistics 2020: GLOBOCAN Estimates of Incidence and Mortality Worldwide for 36 Cancers in 185," *cacancerjournal.com,* vol. 71, 2021.

[2] "Cancer.Net," march 2023. [Online]. Available: https://www.cancer.net/cancer-types/head-and-neck-cancer/statistics.

[3] Srivastava, Shiv p; Cheng, Chee-Wai ; Das, Indra J;, "The dosimetric and radiobiological impact of calculation grid size on head and neck IMRT," *Practical Radiation Oncology,* vol. 7, 2017.

[4] Kim, Kyeong-Hyeon; Chung, Jin-Beom ; Suh, Tae Suk; Kang, Sang-Won; Kang, Seonghee; Eom, Keun-Yong; Song, Changhoon; Kim, In-Ah; Kim, Jae-Sung;, "Dosimetric and radiobiological comparison in different dose calculation grid sizes between Acuros XB and anisotropic analytical algorithm for prostate VMAT," *PLOS ONE,* vol. 13, 2018.

[5] Y. Elcim, B. Dirican and O. Yavas, "Dosimetric comparison of pencil beam and Monte Carlo algorithms in conformal lung radiotherapy," *Applied Clinical Medical Physics,* vol. 19:5, pp. 616-624, 2018.

[6] T. Cao, Z. Dai, Z. Ding, W. Li and H. Quan, "Analysis of different evaluation indexes for prostate stereotactic body radiation therapy plans: conformity index, homogeneity index and gradient index," *Prec Radiat Oncol.,* vol. 3, pp. 72-79, 2019.

[7] , Burela; Soni, Tej Prakash; Patni, Nidhi ; Natarajan, Thiru ;, "Adaptive intensitymodulated radiotherapy in headandneck cancer: A volumetric and dosimetric study," *Cancer Research and Therapeutics,* vol. 15, 2019.

[8] N. Buciuman and L. G. Marcu, "Is there a dosimetric advantage of volumetric modulated arc therapy over intensity modulated radiotherapy in head and neck cancer?," *National library of medicine,* vol. 11, 2022.

[9] Feygelman, Vladimir ; Latif, Kujtim ; Bowers, Mark ; Greco, Kevin ; Moros, Eduardo G; Isacson, Max; Angerud, Agnes ; Caudell, Jimmy ;, "Maintaining dosimetric quality when switching to a Monte Carlo dose engine for head and neck volumetric-modulated arc therapy," *Applied Clinical Medical Physics,* vol. 23, 2022.

[10] Tai, Duong Thanh; Oanh, Luong Thi; Phuong, Pham Hoai ; Sulieman, Abdelmoneim ; Abolaban, Fouad A; Omar, Hiba; Chow, James C.L.;, "Dosimetric and radiobiological comparison in head-and-neck radiotherapy using JO-IMRT and 3D-CRT," *Biological sciences,* vol. 29, 2022.

[11] Nishi, Tamaki ; Nishimura, Yasumasa ; Shibata, Toru ; Tamura, Masaya ; Nishigaito, Naohiro ; Okumura, Masahiko ;, "Volume and dosimetric changes and initial clinical experience of a two-step adaptive intensity modulated radiation therapy (IMRT) scheme for head and neck cancer," *Radiotherapy and oncology,* vol. 106, 2013.

[12] Kathirvel, Murugesan ; Subramani, Vellaiyan; Subramanian, V.S.; Swamy, Shanmugam Thirumalai; Arun, Gandhi; Kala, Subramanian;, "Dosimetric comparison of head and neck cancer patients planned with multivendor volumetric modulated arc therapy technology," *Cancer Research and Therapeutics ,* vol. 13, 2017.

[13] E. G. El-Ghoneimy, M. A. Hassan, M. F. El-Bestar, O. M. Othman and K. N. Mashhour, "A dosimetric comparative study between conformal and intensity modulated radiation therapy in the treatment of primary nasopharyngeal carcinomas: the Egyptian experience," *Clinical Oncology,* vol. 11, 2012.

[14] "The International Commission on Radiation Units and measurements," *the ICRU,* vol. 10, 2010.

[15] M. Yoon, S. Y. Park, D. Shin, S. B. Lee, H. R. Pyo, D. Y. Kim and K. H. Cho, "A new homogeneity index based on statistical analysis of the dose–volume histogram," *APPLIED CLINICAL MEDICAL PHYSICS,* vol. 8, 2007.

[16] Cao, Tingting; Dai, Zhitao; Ding, Zhen; Li, Wuzhou; Quan, Hong;, "Analysis of different evaluation indexes for prostate stereotactic body radiation therapy plans: conformity index, homogeneity index and gradient index," *Precision Radiation Oncology,* vol. 3, pp. 72-79, 2019.

[17] RIET, ARIE VAN'T ; MAK, AD C.A.; MOERLAND, **MAFUNUS** A.; ELDERS, LEO H.; ZEE, WIEBE VAN DER;, "A CONFORMATION NUMBER TO QUANTIFY THE DEGREE OF CONFORMALITY IN BRACHYTHERAPY AND EXTERNAL BEAM IRRADIATION: APPLICATION TO THE PROSTATE," VOL. 37, 1997.

[18] C. Bosse, G. Narayanasamy, D. Saenz, P. Myers, N. Kirby, K. Rasmussen, P. Mavroidis, N. Papanikolaou and S. Stathakis, "Dose Calculation Comparisons between Three Modern Treatment Planning Systems," *J Med Phys,* vol. 45, 2020.

[19] C. M. C. Ma, I. J. Chetty, J. Deng, B. Faddegon, S. B. Jiang, J. Li, J. Seuntjens, J. V. Siebers and E. Traneus, "Beam modeling and beam model commissioning for Monte Carlo dose calculation-based radiation therapy treatment planning: Report of AAPM Task Group 157," *American Association of Physicists in Medicine,* vol. 1, 2020.

[20] S. J. Kim, s. k. kim and D. H. Kim, "Comparison of Pencil-beam, Collapsed-cone and Monte-Carlo Algorithms in Radiotherapy Treatment Planning for 6-MV photons," *Journal of the Korean Physical Society,* vol. 67, pp. 153 - 158, 2015.

[21] Tai, Duong Thanh; Oanh, Luong Thi; Phuong, Pham Hoai ; Sulieman, Abdelmoneim; Abolaban, Fouad A; Omer, Hiba; Chow, James C.L.;, "Dosimetric and radiobiological comparison in head-and-neck radiotherapy using JO-IMRT and 3D-CRT," *Saudi Journal of Biological Sciences,* 2022.

[22] Rakesh, Amrita ; Goyal, Jaishree ; Soni, Sweta ; , Abhilasha; Rastogi, Kartick ;, "A Comparative Study of Planning and Dosimetry in Locally advanced head and neck cancer: sequential versus simultaneous integrated boost methods in intenisity modulated radiotherapy," *Radiation and Cancer Research,* 2022.

تأثير تغيير أحجام الشبكة وخوارزميات حساب الجرعة على العوامل الدوزمترية لمرضى سرطان الرأس والرقبة

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تهدف هذه الدراسة إلى دراسة تأثير تغيير أحجام الشبكة وخوارزميات حساب الجرعة على خطط العلاج الإشعاعي المعدل الكثافة (IMRT) لحالات سرطان الرأس والرقبة (H&N). تم إنشاء خطط العلاج باستخدام تقنية IMRT في نظام تخطيط العلاج TPS) ®MONACO) الذي يدعم الحسابات باستخدام خوارزميات حسابية مختلفة وهي Monte Carlo) MC) و Pencil Beam (PB). تم إنشاء خطط بأثر رجعي لأحد عشر مريضًا تم علاجهم بالفعل من سرطان الرأس والرقبة. تم استرجاع ١١ خطة علاجية وإعادة الحسابات عن طريق التغيير بين حجم الشبكة (٢، ٣، ٤، ٥ مم) والخوارزميات (MC وPB) لكل مريض. تُستخدم معاييرقياس الجرعات ICRU لتقييم الخطط المختلفة في هذه الدراسة. المعايير المستخدمة لحجم الهدف (PTV) هي الجرعة القصوى (Dmax) والحد الأدنى للجرعة (Dmin) والجرعة المتوسطة (Dmean)، ٥٪ D، ٩٥٪ V ، ومؤشر التجانس (HI)، ومؤشر المطابقة (CI) ومؤشر التدرج (GI). وبالنسبة للأعضاء المعرضة للخطر (OARs) تم استخدام الجرعة القصوى (Dmax)، والجرعة المتوسطة (Dmean)، بالنسبة لحجم الجسم كله (WB) تم استخدام الحجم الذي يتلقى ٢ غراي (V2GY) و٥ غراي (V5GY). تم تحليل جميع الخطط للمرضى. وقد أظهرت النتائج فيما يتعلق بـمؤشر التجانس ومؤشر المطابقة HI) وCI)، تظهر خطط MC نتائج أفضل من خطط PB. في حجم الشبكة مقاس ٣ مم، كان مؤشر التجانس يساوي ٠,٢٤ ±٠,٠٨ لـ MC و٠,٢٦ ±٠,٠٧ لـ PB بقيمة P <٠,٠٥. في حجم الشبكة مقاس ٥ مم، كان مؤشر المطابقة يساوي ٠,٩٣ ±٠,٠٤I لـ MC و٠,٩٥ ±٠,٠٤ لـ PB بقيمة P <٠,٠٥. تُظهر مقارنة الخوارزميات بنفس حجم الشبكة (مع قيمة P <٠,٠٥) في جميع معاملات PTV (باستثناء الحد الأدنر للجرعة ومؤشر التدرج المعدل). تظهر مقارنة أحجام الشبكة بنفس الخوارزمية فارق في الجرعة الفصوى والمتوسطة و٥٪ D و٩٥٪ V و CI٢ فقط. عند حجم الشبكة مقاس ٢ مم، كانت الجرعة القصوى تساوي ٧٤,٢٦ ±٤,٤٧ لـ MC و٧٦,٣٤ ± ٥,٠٣ لـ PB، وكانت الجرعة المتوسطة تساوي ٦٢,٨٨ ± ٢,٠٢ لـ MC و٦٣,٨٢ ± ٢,٢٨ لـ PB، وكان ٥٪ D ٦٨,٥٥ ±٤,٢٠ لـ MC و٧٠,٢٠ ± ٤,٤٠ لـ PB، وكان ٩٥٪ V ٩٥,٧٩ ± ١,٠٩ لـ MC و ٩٦,٩٠ ± ٠,٧٠ لـ PB و CI٢ كان ٠,٩٤ ± ٠,٠٥ لـ MC و ٠,٩٥ ± ٠,٠٤ لـ PB.