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OPTIMIZATION OF 3DCRT FOR PAROTID GLAND CANCER

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ABSTRACT
The aim of this study was to compare radiation doses received by the target volume (PTV) using five different parotid irradiation techniques aiming to achieve the optimum technique. This study included eleven patients diagnosed as having parotid gland cancer and subjected to CT simulation and scans were transferred to the treatment planning system. Target volumes and OARs which included spinal cord, brain stem, contralateral parotid and eyes were contoured. Five plans were done, they included the applying of Ipsilateral oblique wedged photon pair (plan 1), Pair of oblique wedged photon and direct lateral field (plan 2), Ipsilateral mixed photon- electron beams (plan 3), Ipsilateral oblique photon pair beam and anterior oblique beam (plan 4), and four-field oblique beam technique (plan 5). For the five plans, statistical analysis was performed on the target volume dose coverage. Analysis of 3DCRT of parotid gland tumors revealed that the four fields oblique technique (plan 5) and ipsilateral oblique photon pair beam and anterior oblique beam technique (plan 4) showed the lowest average of $PTV_{max\ dose\%}$ and highest dose coverage (QI) to the PTV, while mixed photon-electron beam technique (Plan3) contributed to the highest $PTV_{max\ dose\ \%}$ and lowest dose coverage (QI) to the PTV as compared to the other photon techniques. In conclusion: 3DCRT planning technique for parotid gland tumors by using the ipsilateral oblique photon pair beam and anterior oblique beam (plan 4). Technique may be considered as a class solution for the treatment of parotid gland tumors without the need to a complex technique as four-field oblique beam technique (plan 5).

KEYWORDS: 3DCRT; parotid gland cancer; radiotherapy techniques; dose to the PTV.

INTRODUCTION
Parotid tumors are the largest salivary gland tumors. Parotid gland tumors comprise 3% of all head and neck tumors [9, 13, 17]. The treatment volume generally includes the ipsilateral parotid bed and the upper neck nodes [16]. Surgery is the primary treatment of choice, but local recurrence occurs in 20 ±70% of patients. For most patients, adjuvant radiotherapy is recommended, and retrospective studies suggest that this combined modality treatment is associated with a reduction of the local recurrence rate to 5 ±40% [3, 4, 6, 12]. Radiation is commonly administered using linear accelerator of 6 MV-energy using different irradiation techniques[8,17]. The information included a 3D dose distribution is condensed into dose-volume histograms (DVHs) which are essentially graphical demonstration of dose distributions exactly the target volume and organ at risk (OAR)[1,3,5,9]. One of concern and challenge issue of radiotherapy is that the treatment of these tumors with irregular surface due to the presence of external ear and region of different physical electron density (air cavities, dense bone, soft tissue)[2, 11]. Existing of the heterogeneous tissues, internal in homogeneity and also the diverse external contour yield an inhomogeneous dose distribution. Therefore some of the consequences of a heterogeneous treatment volume led to under dose of tumor (target volume) and over dose of critical structures[1, 10, 16].

MATERIALS & METHODS
This study included (11) patients who were diagnosed as having parotid gland cancer**.** Computed tomography simulation (CT simulation) was done for each patient to obtain 3D anatomical data for treatment planning purposes. All patients were immobilized using individual thermoplastic head mask with thermoplastic shoulder fixation and had CT Simulation of slice thickness of (3-5) mm, then the CT data exported to the treatment planning system. The treatment volume generally includes the ipsilateral parotid bed and the upper neck nodes. Dose constraints prescribed by the physician for the organs-at-risk are given for each patient**.** The dose was prescribed for the contoured volumes (TV) and OAR_S, which included (contralateral parotid, spinal cord, brain stem, R&L eyes) by the oncologist according to the International Commission on Radiation Units (ICRU) guidelines [9, 11]. For each patient five different planning techniques were done (Ipsilateral oblique wedged photon pair, pair of oblique wedged photon and direct lateral field, Ipsilateral mixed photon- electron beams, Ipsilateral oblique photon pair and anterior oblique field and Four-field oblique beam technique). Each technique was set according to the variation in its energy, the change in gantry angle, collimator angle, wedge angle, beam weight and dose value. In all of the five plans the photons' energy value was (6MV), except in plan 3 where mixed photon-electron beam was used with (14MeV) for the electron beam and 6 MV for the photon beam [3]. The used bolus thickness was (1 – 1.5) cm also the same in the five plans because of the superficial position of the glands to improve the coverage of the photon buildup region. The daily dose of each plan was not exceeding 200cGy. The specification of each plan technique is given in tables (1, 2, 3, 4 and 5).

TABLE 1: Plan1 Ipsilateral oblique wedged photon pair

Beam no.	Gantry angle ( )^0		Collimator angle ( )^0	Wedge angle ( )^0	Beam weight %	Dose (cGy)
	Rt. Parotid	Lt. Parotid				
1	215-225	35-45	270	30-45	50	100
2	315-325	135-145	270	30-45	50	100

TABLE 2: Plan 2 pair of oblique wedged photon and direct lateral field

Beam no.	Gantry angle ( )^0		Collimator angle ( )^0	Wedge angle ( )^0	Beam weight %	Dose (cGy)
	Rt.Parotid	Lt. Parotid				
1	205-225	15-35	270	30-45	33-42	66-83
2	315-325	125-150	270	30-45	33-42	66-83
3	270	90	0	_	16-34	33-68

TABLE 3: Plan3- Ipsilateral mixed photon- electron beams

Beam no.	Gantry angle ( )^0		Collimator angle ( )^0	Wedge angle ( )^0	Beam weight %	Dose (cGy)
	Rt. Parotid	Lt. Parotid				
1	270	90	0	_	20-50	40-100
2	270	90	0	_	50-80	100-160

TABLE 4: Plan4- Ipsilateral oblique photon pair and anterior oblique field

Beam no.	Gantry angle ( )^0		Collimator angle ( )^0	Wedge angle ( )^0	Beam weight %	Dose (cGy)
	Rt.Parotid	Lt. Parotid				
1	215-225	35-45	0/270	open/30-45	21-45	42-90
2	315-327	135-150	0/270	open/30-45	23-50	46-100
3	35-45	315-340	270	15-60	25-40	50-80

TABLE 5: Plan5- Four-field oblique beam technique

Beam no.	Gantry angle ( )^0		Collimator angle ( )^0	Wedge angle ( )^0	Beam weight %	Dose (cGy)
	Rt.Parotid	Lt. Parotid				
1	215-235	35-45	0	_	12-38	25-77
2	315-325	135-150	0	_	26-41	52-82
3	35-45	305-325	0	_	22-35	44-70
4	135-145	205-225	0	_	9-23	18-46

Statistical analysis

Analysis of data was carried out using the available statistical package of SPSS-22 (Statistical Packages for Social Sciences- version 22). Data were presented in simple measures of frequency, percentage, mean, standard deviation, and range (minimum-maximum values). The significance of difference of different means (quantitative data) was tested using Students-t-test. Statistical significance was considered whenever the P value was equal or less than 0.05.

RESULTS

This study showed that the maximum dose percentage that was proposed to be received by the PTV in its higher value in plans 2 and 3. This finding was followed by plan 1 and 4, while the maximum dose percentage appeared to be in its lower value in plan 5 as shown in (Fig 1).

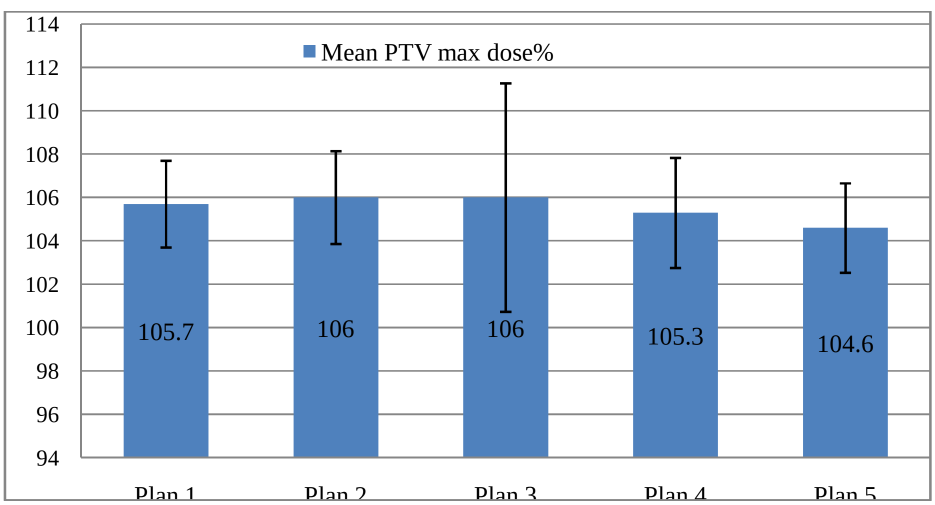

FIGURE 1: Mean of PTV maximum dose percentage in five planning techniques of parotid gland

It was clear that the mean value of PTV maximum dose percentage did not show a significant difference among the five planning techniques.

The mean dose coverage percentage of the PTV which was explained by the (QI) was found to be in its highest value in plan 5, while it had a lowest value in plan 3.

Equal values of OI was appeared in the second and fourth planning techniques, while the QI in the Plan 1 was associated with the same value of the plans 2 and 4 as shown in (Fig 2).

The QI value was significantly higher in plan 1 as compared with plan 3, while this value was significantly the highest in plan 5 than it in plans 1 and 3. The QI showed a significant change in plan 2, where it was higher than plan 3. When comparing the QI value in plan 4, it was significantly higher than in plan 3. No significant change was found in plans 1 vs. 2, 2 vs. 5 and 4 vs. 1 and 5 as shown in table (6).

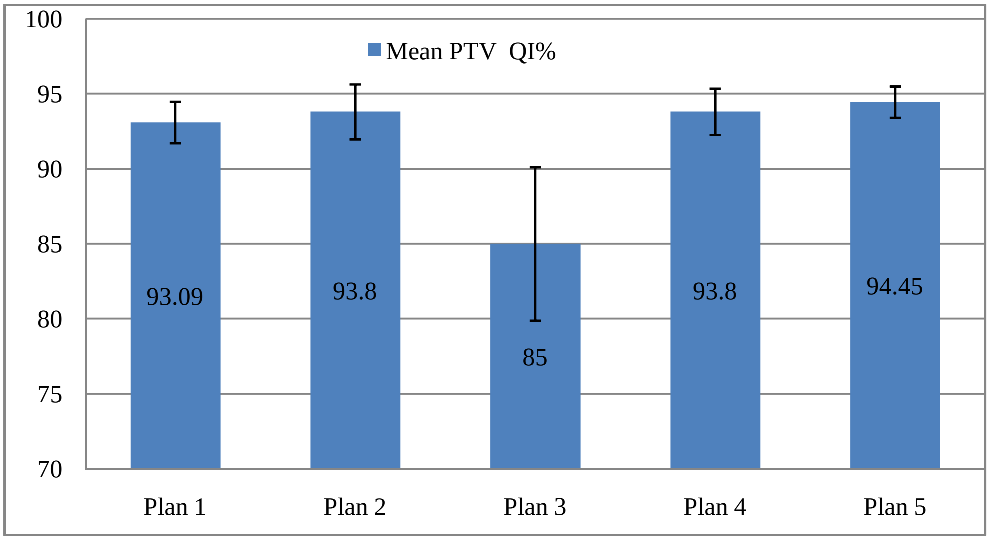

FIGURE 2: Mean of QI percentage of the PTV in five planning techniques of parotid gland

TABLE 6: The P values of QI% of the PTV among five planning techniques of parotid gland

	1	2	3	4	5
1		NS	0.001	NS	0.016
2			0.001	_	NS
3				0.001	0.001
4					NS
5					

DISCUSSION

In the current study, it was found that the average of $PTV_{max\ dose\ \%}$ was the highest in plans 2 and 3 (106%), this may be due to the dose from the direct lateral beam which indeed has been used in both plans (beam 3 in plan 2 and beam 2 (electron beam) in plan 3) where the maximum dose appeared in beam 2 of plan 3 and a high dose value of beam 3 in plan 2, this finding is in agreement with Purdy, et al., 2006 who stated that the lateral photon beam can adequately irradiate the target tissues[14]. The other cause for increasing the $PTV_{max\ dose\ \%}$ in plan 3 is using an electron beam (beam 2). In general, the techniques where an electron beam is utilized contributed to a higher dose heterogeneity compared to photon beam techniques, and this was clearly observed in plan 3. Beam obliquity, surface irregularity, and tissue heterogeneity all modify the beam penetration and depth dose characteristics. These effects are more pronounced for electron beams than for photon beams[16], while the lowest average of $PTV_{max\ dose\ \%}$ appeared in plan 5 (104.6%), the additional fields that were added in this plan by adding beam 4 (E=6Mv) lead to reduce the hot spot areas and extra–target-tissue irradiation and to improve dose distribution [7]. The mean PTV QI% increased gradually with increasing the photon beam numbers, this was appeared in the planning techniques 2, 4, and 5 respectively where PTV QI% was slightly increased by adding a 6Mv photon beam to techniques 2 and 4 rather than plan 1 which included only two beams. Since plan 5 has distinguished by using more photon beams rather than the other planning techniques so that the highest value of the mean PTV QI% was appeared in this plan. The added photon beam in plan 5 was lateral oblique, which may contribute to the significant increase in the mean PTV QI% [15]. Moreover, the using of electron beam technique in plan3 showed the lowest dose coverage, The QI for the PTV was (85%) and significantly reduced compared with other photon techniques (plans 1, 2, 4 and 5). This result is in accordance with the result of Helal *et al*., who found that using mixed photon – electron beam showed the lowest dose coverage to the parotid gland tumours as compared with photon beams techniques[8].

CONCLUSION

The four fields oblique technique (plan 5) and apsilateral oblique photon pair beam and anterior oblique beam (plan 4) considered the best for the treatment of the parotid gland as compared with the other applied techniques because they showed the best highest dose coverage to the target volume.

For plan 5, increasing the beams' number to four did not perform any advantages in comparison with plan 4.

In the present work the mixed photon-electron beam technique (Plan3) contributed to the lowest dose coverage to the target volume as compared with the other photon techniques. Therefore, this planning technique can't be considered as a class solution for the treatment of parotid gland tumors

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