RESEARCH ARTICLE

Multi-segments conformal plan optimization for head and neck cancer

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Abstract

Objective: To evaluate better dose distribution with three-dimensional radiation therapy, and to compare it with multi-segmented treatment planning techniques in patients with head and neck cancer.

Method: The prospective study was conducted at the Baghdad Centre for Radiation Therapy and Nuclear Medicine, Baghdad, Iraq, and comprised data of 50 patients with head and neck cancerous tumours from June 2021 to February 2022. There were 35 (70%) females and 15(30%) males. The mean age was 47.31 ± 3.95 years (range 19 – 69 years The patients had undergone computed tomography simulation. The images were exported to Monaco 5.1 for contouring by the radiation oncologist. The data was then imported to XiO planning system. Each plan was repeated twice; once with three-dimensional conformal radiation therapy and the other with field-in-field technique. Data was analysed using SPSS 24.

Results: There were 50 patients whose data was analysed. The results showed significant differences between three-dimensional conformal radiation therapy and field-in-field techniques for dose coverage at 90% and 95% volumes ($p<0.05$). There was a significant difference between the two techniques for 2Gy dose ($p<0.05$), but the difference was not significant for 5Gy dose ($p>0.05$).

Conclusion: The field-in-field treatment planning technique was found to be more effective than the three-dimensional conformal radiation therapy technique.

Key Words: Nuclear, Radiation, Head and Neck Neoplasms, Tomography, Radiotherapy, X-rays

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Introduction

Head and neck squamous cell carcinoma (HNSCC) accounts for 90% of all malignant diseases in the head and neck region of the body. HNSCC is a disease of older males aged 60-70 years with heavy tobacco use, alcohol abuse, poor diet, and bad dentition.[1-3] HNSCC is treated using high-energy photon beams, such as X-rays and gamma rays[4]. Mechanisms of photon interactions are done by transferring energy from the photons to the irradiated material, where it ultimately dissipates as heat.[5-7].

The term 'linear accelerator' refers only to the portion of the system that accelerates electrons to the desired energy level. However, in this treatment, the phrase refers to the whole system utilised to deliver radiation. The accelerator generates a high-voltage X-ray beam with the properties required for contemporary radiation treatments.[8]

Three-dimensional conformal radiation therapy (3D-CRT) treatment planning refers to the process of developing and delivering radiotherapy treatment plans based on 3D imaging data with treatment fields that are uniquely tailored to treat target tissue and designate target volumes. The software tools allow the localisation/segmentation of the target and volume of interest,[9-11] image reconstruction, automated and beam's eye view of field designs, 3D dosage estimates, and visualisation approaches and metrics for plan assessment.[12,13]

Intensity-modulated beams may be created in 3D planning using a few multi-leaf collimators (MLC)-shaped "segments" all positioned at the same gantry angle. As with intensity-modulated radiation treatment (IMRT), this "segmental", or field-in-field (FIF) approach may be constructed using either the standard interactive planning paradigm.[11] Additionally, when 3D planning is possible, employing a few segments to increase target homogeneity expands the notion of wedged tangents.[13]

The current study was planned to evaluate better dose distribution with 3D-CRT and to compare it with a multi-segmented treatment planning system (TPS) in HNSCC patients.

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Materials and Methods

The prospective, clinical study was conducted at the Baghdad Centre for Radiation Therapy and Nuclear Medicine, Baghdad, Iraq, and comprised data of HNSCC patients from June 2021 to February 2022. Approval was obtained from the ethics review committee of the College of Medicine, Mustansiriyah University, Baghdad. Written informed consent was obtained from all the participants prior to their enrolment. The sample was raised using convenience sampling technique. The sample size comprised all available patients within the defined timeframe. The patients underwent computed tomography (CT) simulation and the images were exported to Monaco 5.1 software workstation for contouring by the radiation oncologist. The data was then imported to the XiO planning system manufactured by Elekta, Sweden. Each plan was repeated twice; once with 3D-CRT and the other with FIF. The X-ray photon energy used was 6 MV.

Data was analysed using SPSS 24. Data was expressed as mean and standard deviation values Which were compared using t-test. $P<0.05$ was considered significant.[14]

Results

There were 50 patients whose data was analysed. The female was higher than male in this study (female: 35 (70%), male 15 (30%)). The mean age was 47.31 ± 3.95 years (Range 19 – 69 years). FIF had a significantly higher dose for both 90% and 95% coverage than 3D-CRT (Table 1).

Table-1: Comparison between 90% and 95% dose coverage for the planning target volume using 3D-CRT and FIF techniques.

Parameters	3D-CRT Mean ± SD (%)	FIF Mean ± SD (%)	p-value
D_{95}%	92.004 ± 4.44	93.40 ± 3.65	0.011259*
D_{90}%	97.661 ± 1.94	98.39 ± 1.55	0.003164*

*Significant Difference at p-value Level 0.05 with One Way using paired T-Test.
3D-CRT: Three-dimensional conformal radiation therapy, FIF: Field-in-field, SD: Standard deviation, D: Dose.

Table-2: Comparison between 3D-CRT and FIF techniques for minimum dose that reached the target.

Parameters	3D-CRT Mean ± SD (%)	FIF Mean ± SD (%)	p-value
$D_{2\,Gy}$	57.13 ± 14.37	54.60 ± 13.40	<0.00001**
$D_{5\,Gy}$	47.22 ± 13.18	47.81 ± 15.03	0.534896

*Significant Difference at p-value Level 0.05 using paired T-Test.
3D-CRT: Three-dimensional conformal radiation therapy, FIF: Field-in-field, SD: Standard deviation, D: Dose.

D2Gy dose using FIF was significantly lower than 3D-CRT, while there was no significant difference between the techniques at D5Gy dose (Table 2).

Discussion

The oncologist evaluates many parameters in treatment planning and calculates the dose coverage. For example, some oncologists depend on the volume that receives 90% of the total dose, and others believe 95% is better.[15] The current study found that FIF could deliver higher doses than the 3D-CRT technique.

Lee et al.[16] planned a forward plan of multi-segment technique (FPMS) that was expected to be defined in depth as an alternative treatment approach for patients not appropriate for inverse-planned treatment and found that FPMS completed IP-IMRT plans and was a suitable alternative care technology.

The current study found that D2Gy and D5Gy low doses could be used to measure plan quality. The FIF showed a significantly lower value than 3D-CRT for D2Gy, but not for D5Gy. The variation in these values may be due to the mechanism of the 3D-CRT that uses a wedge to acquire a higher dose homogeneity in the target, thus resulting in an undesirable dose for the patient. However, FIF attempts to reduce the excess scattered dose by replacing the wedge with the field segments, and lowering the dose to the peripheral margins.

Prabhakar et al.[17] reported that FIF offered comparable dosimetric outcomes as a wedge therapy programme. It is easier for most sites with a significant decrease in control units than wedge preparation for the overall dosage. In addition, FIF increases the homogeneity of dosage delivery across most sites. Therefore, they believed that it was necessary to substitute wedge filters with FIF in preparing radiation therapy.[17]

Limitation: The current study has limitations as the sample size was not calculated owing to time constraints for data collection. This could have influenced the power of the study.

Conclusion

FIF treatment planning technique could distribute the dose more homogeneously and with higher doses than 3D-CRT. Also, FIF could give a lower excess dose than 3D-CRT.

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