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ORIGINAL RESEARCH ARTICLE

3-Dimensional Conformal Radiotherapy versus Intensity Modulated Radiotherapy in Postoperative Head and Neck Cancers: Comparative Analysis of Dosimetric Parameters and Toxicities

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ABSTRACT

Introduction: Post-surgery radiotherapy is an important adjuvant modality in the treatment of locally advanced head and neck cancers. Both 3D-CRT and IMRT represent a significant advance over conventional radiotherapy because they increase dose delivery accuracy while sparing surrounding normal tissues and organs at risk (OAR). India is a developing country that has a heavy burden of head and neck malignancy patients and the radiotherapy facilities are not yet fully developed to provide treatment to every individual by IMRT technique. The aim of this study is to evaluate whether 3DCRT technique is equivalent to IMRT technique in terms of tumor control and sparing of critical normal tissues.

Material And Methods: For the present study, 50 postoperative patients of head and neck malignancies were selected and randomized in two groups of 25 each- Group I (3DCRT) and group II (IMRT) from February 2021 to August 2022. The patients were immobilized on base plate in an extended neck position. Contrast enhanced CT (CECT) scan radiotherapy planning (RTP) of 3 mm slice thickness was obtained in a supine position with three radio-opaque fiducial markers. The delineation of various target volumes (gross, clinical and planning) was done along with the delineation of organs at risk. The dose constraints given for the OARs. All the patients were planned either for 3DCRT or IMRT techniques. The total prescription dose was 60 in 30 fractions in 6 weeks. The dosimetric assessment was done for PTV parameters (V95, D_{max}, D_{mean}, D2, D50, D95 conformity index (CI), Homogeneity index (HI)) and various OARs. The patients were assessed for objective tumor response according to WHO criteria and radiation toxicities. Radiation therapy oncology group acute and late morbidity scoring criteria. The statistical analysis was done using standard statistical methods and software to calculate level of significance using *p-value* with an unpaired T-test.

Results: The majority of patients were in the age group of 41 to 50 years with the mean age in groups 1 and 2 being 48.6 and 45.6 years, respectively. Male patients were dominant with sex ratio 7.3. The primary sites involved were tongue (42%), buccal mucosa (34%), lower alveolus (10%), gingiva-buccal sulcus (8%), larynx (4%) and retromolar trigone (2%). Early stages (Stage I and II) were little higher in 3DCRT group (44 *vs* 28%), while advanced cases were more in IMRT group (72 *vs* 56%). The PTV dose parameters were acceptable in both groups. The homogeneity index was better in IMRT but did not show statistical significance. However, the conformity index was better and statistically significant in IMRT group (1.23 *vs* 1.46, p = 0.03). Dose constraints were achieved in both groups in PRV brainstem, PRV spinal cord, optic chiasma, optic nerves, and cochlea. The dose constraints was not achieved for parotid glands in either group, though it is lower and statistically significant in IMRT group (33.69 Gy *vs* 52.41 Gy, p = 0.00). The mandible dose constraints were not achieved in the 3DCRT group (64 Gy) but in the IMRT group (61.6 Gy). Similarly, dose constraints was not achieved for lips in 3DCRT but was significantly lower and achieved in IMRT group (27.18 Gy *vs* 33.02 Gy, p = 0.00) (Table 2). In group I, 21 (84%) patients showed a complete response while in group II 22 (88%) patients showed a complete response. In acute reactions, there were no grade 3 or 4 skin reactions. In chronic reactions, xerostomia and loss of taste was seen in very less patients and almost similar incidences in both groups (xerostomia 16 *vs* 8%, loss of taste 12 *vs* 16%)

Conclusion: 3DCRT can be given to socio-economically low or middle-class patients who cannot afford IMRT with comparable tumor control. Thus, 3DCRT can be termed as poor man's IMRT' as it is cost-effective.

Keywords: Three-dimensional conformal radiotherapies, Intensity-modulated radiotherapy postoperative head and neck cancers, Dosimetric parameters, Toxicities

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INTRODUCTION

Post-surgery radiotherapy is an important adjuvant modality in the treatment of locally advanced head and neck cancers. It aims to deliver maximum or optimum doses to the target volume while sparing normal tissue and organs at risk (OAR). This fundamental idea of radiation therapy has influenced the development of newer radiation therapy techniques like 3-dimensional conformal radiotherapy (3D-CRT) and intensity-modulated radiotherapy (IMRT).

Initially, the development of radiotherapy started from conventional radiotherapy techniques based on bony landmarks using two-dimensional data. Later, with the advent of three-dimensional imaging techniques, conformal techniques developed. Both 3D-CRT and IMRT represent a significant advance over conventional radiotherapy because they increase dose delivery accuracy while sparing surrounding normal tissues and organs at risk (OAR).

The delivery of 3DCRT/IMRT is accomplished with a set of fixed radiation beams, which are shaped using the projection of the target volume. Geometric modulation of beam shape is done so that it conforms as closely as possible to the target volume in terms of adequate dose to the tumor and minimal possible dose to normal tissue. IMRT has an advantage over 3DCRT in terms of modulation of beam intensity, which will help in better radiotherapy planning and delivery.

The IMRT technique gives the ability to create treatment fields with varying beam intensity using inverse planning and optimization algorithms.[1] The irradiation beam can be adjusted to the irregularly shaped target volumes with high precision while reducing the radiation delivered to the surrounding healthy tissue and critical structures such as spinal cord, brain stem, parotid glands, eyes, optic nerves, chiasm, lacrimal glands, cochlea, and mandible in case of HNC.

3DCRT utilizes forward planning with beam orientations and MLCs designed to cover the PTV optimally and spare the OARs. Comparatively, the IMRT technique uses inverse planning optimization algorithms to create treatment fields with varying beam intensity and more conformal dose distributions thus allowing for better sparing of normal tissue thus minimizing toxicity.[2] The ability to deliver lower radiation doses to normal tissue while maintaining or increasing the dose in the target volume makes IMRT the most appropriate treatment option compared to conventional radiotherapy.[3] However, IMRT technique is not without its disadvantages, including an increase in treatment costs and a higher total body integral dose, which have implications not merely related to economic burden. IMRT's merits must be weighed against the demerits to justify its utilizations.

India is a developing country which has heavy burden of head and neck malignancy patients and the radiotherapy facilities are not yet fully developed to provide treatment to every individual by IMRT technique. The aim of this study is to evaluate whether 3DCRT technique is equivalent to IMRT technique in terms of tumor control and sparing of critical normal tissues. The present study compares the dosimetric parameters and toxicities of two radiotherapy techniques - 3D CRT and IMRT- in patients with postoperative head and neck cancers.

MATERIAL AND METHODS

For the present study, post-operative 50 patients of head and neck malignancies were selected and randomized in two groups of 25 each- group I (3DCRT) and group II (IMRT) from February 2021 to August 2022.

Patient Selection

Inclusion criteria

Post-operative cases of squamous cell carcinoma head and neck cancer malignancies; age >18 years; Karnofsky performance status >70, normal hemogram, renal and liver function tests and normal ECHO.

Exclusion criteria

Patient with positive margins, extranodal extension in histopathology, any indication of concurrent chemotherapy, inoperable and metastatic cases, patients with prior or synchronous malignancy, previously treated patients with radiotherapy

Randomization

Patients were randomly assigned in a 1:1 ratio into two groups (25 each) as follows: Group I- radiotherapy was planned using the 3DCRT 5 field technique, and group II- radiotherapy was planned using the IMRT technique.

Radiotherapy Planning and Technique

The patients were immobilized on base plate in an extended neck position using a fixed five-point thermoplastic cast, with individualized supportive neck rest marking is done with the help of lasers and fiducial markers. Contrast-enhanced CT (CECT) scan radiotherapy planning (RTP) of 3 mm slice thickness was obtained in a supine position with three radio-opaque fiducial markers. These images were then transferred through Digital Imaging and Communications in Medicine (DICOM-CT) into the eclipse treatment planning system {TPS} (Version 13.6, Varian Medical System, Inc., Palo Alto, CA, US). After transferring to TPS, the CT origin moved to the intersection of plane of the fiducial marker.

Delineation of Structures

- Gross tumor volume (GTV): Gross residual disease if any.
- Clinical target volume (CTV) primary: Post-operative bed of primary
- Clinical target volume (CTV) nodal: Defined as draining nodal region related to primary. Department protocol follows guidelines of delineation of neck node level for head and neck tumors as described by BiauJ *et al.*[4]
- CTV final: The inclusion of CTV primary and CTV nodal.
- Planning target volume (PTV): A symmetrical margin of 5 mm was taken from CTV to account for patient setup error (As per institutional protocol)
- Organ at risk structures (OARs) delineation: The OARs delineated will be left and right parotid glands, spinal cord, brain stem, eyes, lens, optic chiasma, optic nerve, cochlea (right & left), lips and mandible. They will be delineated as per DAHANCA[4] guidelines. An isotropic expansion of 5 mm was given for PRV spine and 3 mm for the brainstem.

The dose constraints given for these OARs were PRV brainstem (D_{max} <54 Gy), PRV spine (D_{max}<50 Gy), optic chiasma (D_{max} <55 Gy), optic nerve (D_{max} <55 Gy), cochlea (D_{mean} <45 Gy), mandible (D_{max} <70 Gy, 1cc <75 Gy), parotid glands (D_{mean} <26 Gy), eyes (D_{max} <50 Gy (0.03 cc)), lens (D_{mean} <7 Gy (0.03 cc)) and lips (D_{mean} < 30 Gy).

All the patients were planned either for 3DCRT or IMRT techniques. The total prescription dose was 60 in 30 fractions in 6 weeks.

Dosimetric Parameters

The ideal planning objective was to achieve a minimum dose >95% and a maximum dose <107% of the prescribed dose.

Five field 3D CRT planning technique- Five fields to be created for five different gantry angles. The different angles are G85, G140, G180, G225 and G275. Plan will be normalized for PTV. Each field may have a different weightage since some fields have partial block for PTV. We can use field in field to control the hotspot or max dose within the PTV. Isodose coverage and dose volume histogram (DVH) will evaluate the completed plan. If the coverage of PTV and tolerance to OAR are not achieved, the beam angles and weightage will be adjusted to achieve the goal.

IMRT planning technique-Coplanar 7-9 fields around isocenter using isotropic gantry angles will be used and may be adjusted slightly to avoid the beam entry through OAR's. Inverse planning will be done and in next step of fluence optimization, the dose coverage minimum and maximum required for PTV and dose tolerance to OAR's will be defined. The plan will now be evaluated by isodose coverage and DVH. The plan was compared with an alternate plan, to improve treatment quality. Energy used in IMRT is 6MV with different gantry angles like G0, G40, G80, G120, G160, G200, G240, G280 and G320.

Dosimetric assessment dose–volume histograms (DVHs) corresponding to the delivered 3-D CRT/IMRT plan was generated for each contoured region.

PTV dosimetric parameters for evaluation were as follows:

- V95, D_{max}, D_{mean}, D2, D50, D95 conformity index (CI), Homogeneity index (HI)
- Conformity index (CI): Treated volume (TV)/planning treated volume (PTV), where TV is the absolute volume of 95% reference dose.
- Homogeneity index (HI) :(D2–D98%)/D50%

where, D2% is dose received to 2% PTV, D98% is dose delivered to 98% PTV, D50% is dose delivered to 50% PTV. The planning objective for D50% is defined as equivalent to the prescribed dose.

The doses of each organ at risk (OAR) was quantified.

Clinical Response Assessment

The patients will be assessed for objective tumour response according to WHO criterion: Complete response (CR)- Total tumor regression for at least 4 weeks; Partial response (PR)- 50% or more reduction in product of two major perpendiculars of the measurable tumor for at least 4 weeks; Stable disease (SD)- Less than 50% or more reduction to less than 25% increase in cross product; Progressive disease (PD)- Growth of measurable tumor by 25% or more or appearance of new lesion.

Assessment of Toxicity

- Radiation toxicity (skin, mucosal, taste and salivary glands) will be assessed by radiation therapy oncology group (RTOG) acute and late morbidity scoring criteria.

Statistical Analysis

Collected data was analyzed using standard statistical methods and software to calculate the level of significance using *p-value* with unpaired T-test.

RESULTS

Most of the patients were in the age group of 41 to 50 years, with the mean age in groups 1 and 2 being 48.6 and 45.6 years, respectively. Male patients were dominant with sex ratio of 7.3. The primary sites involved were tongue (42%), buccal mucosa (34%), lower alveolus (10%), gingiva-buccal sulcus (8%), larynx (4%) and retomolar trigone (2%). All patients had a histopathological diagnosis of squamous cell carcinoma, with the majority of cases having well-differentiated (54%) and moderately differentiated (48%) grading.

In clinical examination, positive nodes were seen in 24% cases of 3DCRT group and 28% cases of IMRT group. Early stages (Stage I and II) were little higher in 3DCRT group (44 *vs* 28%), while advanced cases were more in IMRT group (72 *vs* 56%)

The PTV dose parameters were acceptable in both groups. Most parameters were better in the IMRT group and statistically significant, as shown in Table 1. The homogeneity index was better in IMRT but did not show statistical significance. However, the conformity index was better and statistically signicant in IMRT group (1.23 *vs* 1.46, $p = 0.03$)

Dose constraints were achieved in both groups in PRV brainstem, PRV spinal cord, optic chiasma, optic nerves, and cochlea. The dose constraints was not achieved for parotid glands in either groups, though it is lower and statistically significant in IMRT group (33.69 *vs* 52.41 Gy, $p = 0.00$). The mandible dose constraints were not achieved in the 3DCRT group (64 Gy) but in the IMRT group (61.6 Gy). Similarly, dose constraints was not achieved for lips in 3DCRT but was significantly lower and achieved in IMRT group (27.18 *vs* 33.02 Gy, $p = 0.00$) (Table 2)

In group I, 21 (84%) patients showed a complete response while in group II 22 (88%) patients showed a complete response. In group I 8 (26.6%) of the patients showed a partial response while in group II 3 (10%) of the patients showed a partial response. In group I 2 (6.6%) of the patients had a progressive disease, while in group II 1 (3.3%) patient had a progressive disease.

In acute reactions, there were no grade 3 or 4 skin reactions. The majority of patients had grade 1 or 2 oral mucositis (group1 84%, group 2 88%). In chronic reactions, xerostomia and loss of taste was seen in very less patients and almost similar incidences in both groups (xerostomia 16 *vs* 8%, loss of taste 12 *vs* 16%)

Table 1: Dosimetric parameters of PTV of both groups

Dosimetric parameters	*3DCRT (Mean + SD)*	*IMRT (Mean + SD)*	*p-value*
V95	82.38 ± 9.53	97.95 + 2.68	0.001
D_{max} (Gy)	65.61 ± 1.0	63.62 + 1.20	0.00
D_{mean} (Gy)	60.07 + 0.78	59.94 + 1.11	0.49
D2 (Gy)	64.27 + 0.84	61.79 + 0.95	2.98
D50 (Gy)	60.45 + 0.81	60.42 + 0.42	0.45
D95 (Gy)	54.01 + 2.54	58.45 + 2.48	0.001
D98(Gy)	51.51 + 3.75	56.79 + 5.82	0.00
Homogenity index	0.20 + 0.06	0.07 + 0.09	0.11
Conformity index	1.46 + 0.42	1.23 + 0.20	0.03

Table 2: Dosimetric parameters of OARs of both groups

OARS	*3DCRT (Mean + SD)*	*IMRT (Mean + SD)*	*p-value*
PRV brainstem	39.13 + 8.97	28.02 + 8.91	0.00
PRV spinal cord	45.85 + 4.07	38.39 + 6.51	0.00
Optic chiasma	4.40 + 7.92	3.92 + 3.2	0.68
Optic nerve (R)	6.56 + 9.83	4.17 + 3.11	0.24
Optic nerve (L)	5.39 + 7.61	3.91 + 2.71	0.35
Parotid (R)	51.87 + 6.76	33.48 + 17.73	0.00
Parotid (L)	51.28 + 6.85	34.86 + 15.94	0.00
Both parotids	52.41 + 7.87	33.69 + 9.88	0.00
Cochlea (R)	14.54 + 11.98	18.42 + 13.81	0.18
Cochlea (L)	13.99 + 11.51	16.93 + 11.08	0.25
Lips	33.02 + 7.80	27.18 + 6.88	0.00
Mandible	63.99 + 3.39	61.62 + 4.98	0.05

DISCUSSION

The present study compares two radiotherapy techniques - 3DCRT and IMRT in terms of PTV dosimetric parameters and treatment outcomes. In 3DCRT the results of PTV parameters are comparable to IMRT. Since 3DCRT technique is cost effective, it can be used for planning and delivery of radiotherapy in cancer centres where IMRT is not available. We are trying to highlight that 3DCRT should not be underestimated in limited resource centres and can be considered as 'Poor man's IMRT'.

In a study conducted by Cozzi *et al.*,[5] where dosimetric and technical parameters of 3DCRT and IMRT were compared in head-and-neck cancer patients, IMRT plan was superior in terms of both target coverage (V90 and V95) and organ at risk sparing (Spinal cord and parotids). The V95 in 3DCRT arm was 85.4 ± 8.9 and in IMRT arm was 92.9 ± 2.9 with a significant p value of < 0.001. The conformity index in 3DCRT arm was 1.67 ± 0.22 and in IMRT arm was 1.46 ± 0.17 with a significant *p-value* of <0.001.

In our study a total of 5 fields were used in 3DCRT which was delivered in phase wise manner. When dosimetric parameters were compared in our study there is statistically significant benefit for IMRT arm in V95 (82.38 ± 9.53 *vs* 97.95 ± 2.68) with a significant *p-value* of 0.001. The results of V95 are comparable to the above-mentioned study as IMRT uses multiple beams to target the PTV with a better dose distribution as compared to 3DCRT.

Further, in present study the conformity index in 3DCRT arm was 1.46 ± 0.42 *vs* IMRT arm was 1.23 ± 0.20 which is comparable to above mentioned study. As asserted by RTOG that conformity index determines the quality of conformation of tumor and the value as close to 1 is considered better and value below 1.2 is considered acceptable. There is benefit in conformity index in IMRT arm compared to 3DCRT, though in 3DCRT arm the PTV volume coverage was comparable to IMRT. Also, there was no incidence of recurrence in the patients treated with 3DCRT technique. So, we can suggest that we can use 3DCRT technique in places where high end techniques like IMRT are not available or there are financial constraints. It can provide quality treatment without compromising the treatment volume and efficient sparing of critical OARs.

Wiggenraad *et al.*[6] (2005), developed a 3DCRT technique called ConPas - a 3-D conformal parotid gland sparing irradiation technique- for bilateral neck treatment as an alternative to IMRT treatment plans. Using ConPas, the conventional technique were computed for ten consecutive patients with T1-4 N0-1 larynx or hypopharynx carcinoma (not T1 glottic).This study concluded that ConPas technique helps sparing parotid and they concluded that this 3DCRT technique (ConPas) would enable clinically relevant parotid gland sparing in bilateral elective neck irradiation with non-modulated beams, without compromising target coverage. It would be relatively easy to perform in departments that have not yet started an IMRT program.

In another study conducted by Tai *et al.*[7] 3DCRT and IMRT were compared using different radiation dose indices such as CI, HI, PTV, OARs. Dose received by PTVs were quite similar 72.1 ± 0.8 Gy by 3DCRT and 72.5 ± 0.6 Gy by IMRT plan, mean dose received by parotid gland were 56.7 ± 0.7 Gy by 3DCRT and 26.8 ± 0.3 Gy by IMRT technique. HI and CI were 0.13 ± 0.01 and 0.14 ± 0.05, respectively in 3DCRT arm and 0.83 ± 0.05 and 0.73 ± 0.10 by IMRT arm, respectively. This study concluded that when compared to 3DCRT, IMRT treatment plan had increased dose coverage to PTV, improved CI, HI and improved sparing of parotid gland.

In our study it was found that the PTV coverage of IMRT arm was better but comparable when compared to 3DCRT arm, the various parameters that were discussed were D_{max}, D_{mean}, V95, D95, D50 and D98. V95 in 3DCRT arm was 82.38 ± 9.53 and in IMRT was 97.95 ± 2.68 with a `significant *p-value* 0.001. D95 in 3DCRT arm was 54.01 ± 2.54 and in IMRT arm was 58.45 ± 2.48 with a significant *p-value* of 0.001. D98 in 3DCRT arm was 51.51 ± 3.75 and in IMRT arm was 56.79 ± 5.82 with a significant *p-value* of 0.001. Conformity Index in 3DCRT arm was 1.46 ± 0.42 and in IMRT arm was 1.23 ± 0.20 with a significant p value 0.03 CI values have been defined to determine the quality of conformation of tumor volume. Our study shows better homogeneity index in IMRT arm when compared to 3DCRT arm 0.07 ± 0.09 *vs* 0.20 ± 0.06. This result of 5 field are comparable to bellinzona technique which also uses 5 fields, ConPas which uses 7 field and FPMS which uses 7 fields. Homogenous dose distribution is obtained by increasing more fields with subfields. We can provide almost equivalent coverage of the PTV by using 5 field 3DCRT without compromising treatment quality.

In our study dosimetry of organ at risk like Parotids and spinal cord were assessed. The D_{mean} of Right parotid in 3DCRT arm was 51.87 ± 6.76 when compared to IMRT arm the value was 33.48 ± 17.73 the p value was significant (0.00). The D_{mean} of left parotid in 3DCRT arm was 51.28 ± 6.85 when compared to IMRT arm the value was 34.86 ± 15.94 and the *p-value* was significant (0.00). The Dmax of spinal cord in 3DCRT arm was 45.85 ± 4.07 when compared to IMRT arm the value was 38.39 ± 6.51 the *p-value* was also significant (< 0.001). To conclude IMRT technique is better or equivalent to 3DCRT technique in terms of PTV dosimetry and OAR sparing because in IMRT uses multiple fields and each field has different intensities which provides perfect conformity of the tumor volume. In OAR dosimetry, we observe that the parotid mean dose is not achieved in both the arms, but there is no significant difference in the number of patients having long term toxicities like xerostomia and loss of taste sensations. There is no significant difference in late toxicities when IMRT and 3DCRT techniques are compared though a longer follow up is required for proper assessment.

In a retrospective study conducted by Ghosh *et al.*[8] where toxicity profile of IMRT versus 3DCRT in head and neck cancer patients was compared, it concluded that the 3D-CRT group showed noticeably more acute toxic effects than the IMRT group. Three of 40 (7.5%) patients in the IMRT group, 5 of 40 (12.5%) patients in the 3D-CRT group experienced acute grade 3 or higher toxic effects on the skin. About 40% (16 of 40) patients in the IMRT group and 23 of 40 (57.5%) patients receiving 3DCRT experienced acute grade 3 or higher adverse effects to the mucosal membranes. There was statistically significant xerostomia in 29 of 40 patients in the 3D-CRT group (72.5%), compared with IMRT 18 of 40 (45%) patients.

In a study conducted by Van der Veen[9] *et al.* to evaluate whether IMRT can reduce toxicities in head and neck squamous cell carcinoma concluded that that IMRT is safe with no increased risk loco-regional recurrence. IMRT was also beneficial for voice quality and mucositis.

In our study it was observed that in 3DCRT arm 11 out of 25 patients had grade I skin reactions and 14 out of 25 patients had grade II skin reactions when compared with IMRT arm 14 out of 25 patients had grade I skin reactions and 11 out of 25 patients had grade II Skin reactions. Oral mucositis in 3DCRT arm 3 out of 25 patients had grade I oral mucositis, 18 out of 25 patients had grade II oral mucositis and 4 out of 25 patients had grade III oral mucositis when compared with IMRT arm 1 out of 25 patients had grade I oral mucositis, 21 out of 25 patients had grade II oral mucositis, 3 out of 25 patients had grade III oral mucositis. In both IMRT and 3DCRT arms there were no grade III or higher skin reaction

In 3DCRT arm 4 out of 25 patients has grade III oral mucositis more than IMRT arm so to conclude 3DCRT arm has comparable toxicity when compared with IMRT and these toxicities can be managed easily on OPD basis, and rarely on IPD basis. So, 3DCRT technique can be used in patients who have financial constraints and, in those institutions, where IMRT technique is not available we can get almost equivalent results.

A prospective randomised study conducted by Rathode *et al.*[10] which was related to quality-of-life outcomes in patients with head and neck squamous cell carcinoma treated with IMRT compared to 3DCRT concluded that IMRT has comparatively less late toxicities than 3DCRT arm like dry mouth, difficulty in opening mouth, sticky saliva, pain, senses.

In a study conducted by Gupta *et al.*[11] long-term disease-related outcomes and late radiation morbidity between IMRT and 3DCRT was compared in head and neck squamous cell carcinoma (HNSCC). The study concluded that in long-term survivors of non-nasopharyngeal HNSCC, IMRT offers a clinically significant and long-lasting decrease in the incidence of moderate to severe xerostomia and subcutaneous fibrosis compared to 3D-CRT without compromising disease-related outcomes.

In our follow up study at six months it was observed that RTOG grade two or more xerostomia in 3DCRT arm was more when compared to IMRT arm (16 *versus* 8%), though it was not statistically significant.

In a meta-analysis by De Felice *et al.*[12] evaluating xerostomia and clinical outcomes in IMRT and 3DCRT groups concluded that grade ≥ 2 acute xerostomia and late xerostomia at 1 and 2 years after treatment were reduced with the IMRT technique, but was better in terms of clinical outcomes. Its beneficial effects on tumour control and survival have yet to be established.

In a study conducted by Eishburch *et al.*[13] concluded that the conformity of doses produced by IMRT provide the potential for organ sparing and superior dosimetric parameters when compared with 3DCRT technique. Xerostomia which is a late side effect of radiotherapy was also reduced in IMRT arm.

Another study conducted by Dirix *et al.*[14] in which radiation induced xerostomia was assessed in patient undergoing radiotherapy. During three years follow up, 64% of long-term survivors developed moderate to severe xerostomia and reduced quality of life (QoL). This study concluded that use of more conformal techniques like IMRT decreases long term complications like xerostomia.

In our study it was observed that 3 out of 25 in 3DCRT arm had loss of taste sensation when compared to IMRT arm where 4 out of 25 patients had loss of taste sensation at six months. Above mentioned studies concluded that IMRT provides a better QOL in patients but in our study, there was no significant difference observed which may be attributed to smaller sample of patients and shorter follow up period.

Several other studies favour IMRT in terms of lesser long term side effects and better QoL. The study by Nutting *et al.*[15] on parotid sparing intensity modulated versus conventional radiotherapy in head and neck cancers concluded that sparing of parotid by IMRT significantly decreased the incidence of xerostomia and enhanced QoL restoring the salivary output. IMRT had a lower toxicity profile and was safer than 3DCRT. In a study conducted by Tribius *et al.*[16] comparing IMRT with 3DCRT in patients with head and neck cancer concluded that IMRT was associated with improvements in QoL particularly relating to xerostomia including dry mouth sticky saliva and difficulty in eating.

Study conducted by Kouloulias *et al.*[17] in which patients of head and neck carcinoma treated with radiotherapy IMRT techniques were assessed for radiation induced toxicity like xerostomia. In conclusion IMRT lowers late xerostomia when compared to 3DCRT and IMRT is superior in terms of acute mucositis, overall survival and locoregional control.

In a study conducted by Kowai *et al.*[18] in which impact of IMRT was seen in patients of head and neck cancers when compared to 3DCRT and concluded that dermatitis, mucositis, and dysphagia of grade >2 were considerably less common in IMRT arm when compared to 3DCRT arms. Patient treated with IMRT technique were benefitted because survival outcomes were sustained with less toxicities.

In above mentioned studies it is stated that IMRT has comparatively less late toxicities than 3DCRT arm like xerostomia. In IMRT we can save the organs at risk especially parotid glands by giving dose constraints and modulating the intensities of beams. In the present study we have observed that multiple field 3DCRT can obtain comparable results of PTV dosimetric parameters when compared to IMRT.

IMRT is a costly treatment and in developing countries like India, it may not be feasible for majority of the head and neck cancer patients due to lowe or middle-income groups and more so ever due to routine non-practice of getting health insurances. In such scenario, 3DCRT is comparable to IMRT in terms of PTV dose parameters which signifies comparable tumor control.

CONCLUSION

3DCRT can be comfortably be offered to socio-economically low or middle class group of patients who cannot afford IMRT. Further, it is also a feasible option in those centres where IMRT technique is not available and patient's logistic reasons of travel and accommodation to distant places is not possible. Thus, 3DCRT can be termed as Poor man's IMRT' as it is cost effective and comparable in terms of tumor control.

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