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Original Article

PROSPECTIVE STUDY TO EXPLORE THE RELATIONSHIP BETWEEN DOSIMETRIC PATTERN AND QUALITY OF LIFE IN HEAD AND NECK CANCER PATIENTS TREATED BY IMRT

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ABSTRACT

Objective: This prospective study aimed to explore the relationship between dosimetric patterns and quality of life (QOL) outcomes in patients with head and neck cancer (HNC) treated with Intensity-Modulated Radiotherapy (IMRT).

Methods: Conducted at the Department of Radiation Oncology, RNTMC, Udaipur, Rajasthan, from January to December 2023, this hospital-based observational study included 100 patients with histologically confirmed squamous cell carcinoma of the head and neck. Patients underwent IMRT with specific dosimetric parameters targeting various structures while assessing QOL using the EORTC QLQ-C30 and QLQ-HN-35 questionnaires at baseline, 3, and 6 mo post-treatment.

Results: The study encompassed predominantly male patients (89%) with a mean age of 53.02±13.10 y. Tongue cancer was the most common site (38%), followed by oropharynx (16%) and buccal mucosa (14%). Dosimetric analysis revealed that higher mean doses to the left and right parotid glands and constrictor muscles were significantly associated with increased severity of symptoms, impacting QOL negatively. Notably, increased mean doses correlated with more severe issues related to pain, swallowing, sensory problems, speech, and social aspects of eating and contact.

Conclusion: This study underscores the critical impact of dosimetric patterns on the QOL of HNC patients treated with IMRT. Optimizing dosimetric parameters to minimize exposure to critical structures like the parotid glands and constrictor muscles can potentially mitigate treatment-related toxicities, thus enhancing patients' QOL. Future strategies should focus on tailored radiation therapy plans to balance tumor control and preservation of QOL.

Keywords: Head and neck cancer, Quality of life, Intensity-modulated radiotherapy, Dosimetric patterns, Radiation toxicity

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INTRODUCTION

Head and neck cancers (HNCs) encompass a variety of malignancies originating in the upper aerodigestive tract, including the oral cavity, pharynx, larynx, and paranasal sinuses. Over 90% of these cancers are squamous cell carcinomas (SCC). In India, lip and oral cavity cancers are particularly prevalent, representing the second most common malignancy with an incidence rate of 10.3%, according to Globocan 2020 data. Globally, the incidence of HNSCC is projected to rise by 30%, reaching approximately 1.08 million new cases annually by 2030 [1, 2].

The high prevalence of HNSCC in regions like Southeast Asia and Australia is linked to the intake of specific carcinogens, while the United States and Europe see higher rates due to increasing oropharyngeal HPV infections. Men are at a significantly higher risk of developing HNSCC than women, with a two-to-four-fold increased likelihood. The synergistic effects of tobacco and alcohol consumption further elevate this risk.

Managing HNC typically requires a multidisciplinary approach involving surgery, radiation therapy, chemotherapy, and targeted therapy. Treatment choices depend on factors such as the patient's overall health, the primary disease site, clinical stage, and tumor resectability. Approximately one-third of patients present with early-stage disease amenable to curative surgery or radiation therapy, while more than half are diagnosed with locoregionally advanced disease.

Despite advancements in treatment modalities, HNC remains a global health concern with high morbidity and mortality rates. Intensity-modulated radiotherapy (IMRT) has become the standard of care for HNC due to its precision in delivering radiation doses to target volumes while sparing healthy tissues [3-5]. IMRT offers several advantages over conventional radiation therapy, including better target conformity and reduced toxicity. For HNC, the clinical target volume 1 (CTV1) receives a higher radiation dose than CTV2, which includes the primary tumor and involved nodes. IMRT's numerous rotating beamlets of varying dimensions and intensities facilitate optimal treatment planning around irregularly shaped volumes, effectively targeting tumors while avoiding critical anatomical structures.

In the head and neck region, IMRT spares normal structures such as salivary glands, esophagus, optic nerves, brain stem, and spinal cord. It also enables treatment delivery in a single phase without needing additional fields for tumor boosts, eliminating the necessity for electron fields to posterior neck nodes. Simultaneous integrated boost (SIB) IMRT, delivering different dose levels to various target volumes in a single treatment session, has become a widely adopted technique. This method shortens treatment time and allows for increased fraction sizes to boost tumor volumes. Volumetric intensity-modulated arc therapy (VMAT) further enhances therapeutic outcomes compared to the higher monitor unit (MU) delivery of IMRT [6].

The evolution from 2D radiotherapy (RT) to 3D-conformal radiotherapy (3D-CRT) to IMRT marks significant progress in HNSCC treatment, with IMRT offering the most conformal therapy tailored to patient-specific needs [7, 8]. While IMRT reduces normal tissue toxicities such as xerostomia, its improved conformality means anatomic changes due to weight loss or tumor reduction can significantly impact the delivered dose.

Understanding the relationship between dosimetric patterns and quality of life (QOL) outcomes in HNC patients treated with IMRT is crucial for optimizing treatment plans. Dosimetric parameters, including dose-volume histograms (DVH) of target volumes and organs at risk (OAR), are critical for assessing radiation dose distribution. The European Organization for Research and Treatment of Cancer (EORTC) instruments, such as the Core Questionnaire (QLQ-C30) and the Head and Neck Cancer Module (QLQ-HN-35), are used to evaluate QOL. By integrating dosimetric analysis with QOL assessments, this study aims to provide insights into the impact of radiation dose on patient well-being and functional status in HNC [9].

MATERIALS AND METHODS

Study Area: Department of Radiation Oncology, RNTMC, Udaipur, Rajasthan.

Study period: Data collection from January 2023 to December 2023, post-approval from the Institutional Research Review Board, Ethics Committee, and Observational units.

Study universe: Newly diagnosed patients with histologically confirmed squamous cell carcinoma of the head and neck attending the Department of Radiation Oncology.

Sample size: Calculated at 80% study power and α error of 0.05, with a minimum of 92 patients required. A total of 100 patients were included.

Study type and design: Hospital-based prospective observational study.

Inclusion criteria

- Histopathologically proven patients of LAHNSCC.
- AJCC prognostic stage group II-IVA.
- Either sex.
- Karnofsky performance status 70-100.
- Age 18-80 y
- Willingness to give written informed consent.

Exclusion criteria

- Malignancies of the nasopharynx, skin, nose, paranasal sinus, thyroid, salivary gland, sarcoma, and lymphoma.
- Distant metastasis.
- Uncontrolled intercurrent illness.
- Prior head and neck radiotherapy.
- Double malignancy.
- Postoperative cases.

Pretreatment patient evaluation

- Comprehensive head and neck examination.
- Mirror and fiberoptic examination.
- Biopsy of the primary site or fine-needle aspiration (FNA) of neck swelling.
- Haemogram, kidney, and liver function tests.
- HBsAg, Anti HCV, HIV tests.
- CECT and/or MRI with contrast of primary and neck.
- Chest X-ray and CECT Thorax as indicated.
- Dental evaluation.
- Nutrition, speech, and swallowing evaluation/therapy.
- Audiogram.
- Smoking cessation counseling.

Radiation technique

- Included 100 patients of HNC: 9 oral cavities, 15 oropharynx, 6 hypopharynx, and 13 laryngeal cancer.
- All had locally advanced (stage II-IVA) squamous cell carcinoma eligible for curative 3D conformal radiotherapy (IMRT).
- Weekly cisplatin 30 mg/m^2 during RT.
- Patients were immobilized using a thermoplastic mask and scanned with CT from the vertex to the inferior border of the manubrium sterni with 5 mm thickness.
- Organs at risk (OARs) and target volumes were contoured per DAHANCA 2019 guidelines.
- Radiotherapy was administered using an Elekta Compact 6MV photon beam LINAC with IMRT technique. Dose prescription followed ICRU 62 guidelines: 70Gy in 35 fractions to PTV-HR and 54Gy in 35 fractions to PTV-LR.
- Dosimetric data: Parotid glands and pharyngeal constrictor muscles were contoured. The mean dose in Gray (Dmean) was calculated from dose-volume histograms.
- Planning objectives required PTV coverage of 95-107%.
- OAR dose constraints: Parotid glands Dmean<26Gy, Pharyngeal Constrictors Dmean<50Gy.

Dosimetric data

- Analysis included mean dose calculations for parotid glands and pharyngeal constrictor muscles from dose-volume histograms.

RESULTS

Age-wise distribution of cases.

Table 1: Age-wise distribution of cases

Age group	Number	Percentage
16-25	1	1
26-35	4	4
36-45	13	13
46-55	28	28
56-65	34	34
66-75	17	17
76-85	3	3
Total	100	100

The mean age of cases was 53.02±13.10 y.

Table 2: Sex-wise distribution of cases

Sex	Number	Percentage
Female	11	11
Male	89	89
Total	100	100

In our study, the maximum (89%) cases were male, and the remaining 11(11%) were female. Male to female ratio was 8.09:1.

Table 3: Distribution of site of primary lesion

Site of the primary lesion	Number	Percentage
Tongue	38	38
Buccal mucosa	14	14
PFS	8	8
Oropharynx	16	16
Hypopharynx	5	5
Larynx	7	7
Hard palate	3	3
Nasopharynx	9	9
Total	100	100

In head and neck cancer cases, around one-third 38 cases had the tongue as the primary site of lesion, followed by the oropharynx 16, buccal mucosa 14, and least case 3 had the hard palate as the primary lesion site.

Table 4: Tumour classification among study participants

Tumor classification	Number	Percentage
T3	68	68
T4	32	32
Total	100	100.0

Table 5: Node classification among study participants

Node classification	Number	Percentage
N2	64	64
N3	36	36
Total	100	100.0

Table 6: Association of mean dose of radiation to left parotid with severity of symptoms at 6 mo

Symptoms		Lt parotid	P-value
Pain	Mild	16.5±2.38	0.001
	Severe	26.23±12.4	
Swallowing	Mild	16.5±2.38	0.001
	Severe	26.23±12.4	
Senses problem	Mild	18.19±5.99	0.009
	Severe	25.92±12.41	
Speech problem	Mild	16.18±2.01	0.001
	Severe	26.19±12.35	
Social eating	Mild	18.43±9.5	0.002
	Severe	26.42±12.03	
Social contact	Mild	17.33±7.12	<0.001
	Severe	26.81±12.25	
Less sexuality	Mild	19.52±9.46	0.003
	Severe	26.64±12.26	
Teeth	Mild	21.75±9.98	0.033
	Severe	26.51±12.75	
Opening mouth	Mild	21.98±11.51	0.109
	Severe	25.82±12.03	
Dry mouth	Mild	21.75±9.98	0.033
	Severe	26.51±12.75	
Sticky saliva	Mild	21.98±11.51	0.109
	Severe	25.82±12.03	
Coughing	Mild	21.75±9.98	0.033
	Severe	26.51±12.75	
Felt ill	Mild	21.75±9.98	0.033
	Severe	26.51±12.75	

Table depicts the association of mean dose to Lt Parotid gland and the severity of symptoms which were graded Mild and severe according to symptoms score.

The Bar chart data shows the association between increased mean dosages to the Lt. Parotid gland and the severity of symptoms as reported by patients in our study.

Table depicts the association of mean dose to Rt. The parotid gland and the severity of symptoms which was graded as Mild and severe according to the symptoms score.

The Bar chart data shows the association with increased mean dosages to Rt. Parotid gland and the severity of symptoms as reported by patients in our study.

Table 7: Association of mean dose of radiation to right parotid with severity of symptoms at 6 mo

Symptoms		Rt parotid	P-value
Pain	Mild	18.05±2.66	<0.001
	Severe	30.92±11.35	
Swallowing	Mild	18.05±2.66	<0.001
	Severe	30.92±11.35	
Senses problem	Mild	20.87±7.62	0.001
	Severe	30.4±11.47	
Speech problem	Mild	18.12±2.71	<0.001
	Severe	30.79±11.38	
Social eating	Mild	19.12±6.94	<0.001
	Severe	31.57±11.03	
Social contact	Mild	18.39±5.64	<0.001
	Severe	31.91±10.94	
Less sexuality	Mild	19.77±6.38	<0.001
	Severe	32.31±11.1	
Teeth	Mild	23.54±9.54	<0.001
	Severe	32.18±11.37	
Opening mouth	Mild	26.29±10.58	0.109
	Severe	29.98±11.71	
Dry mouth	Mild	23.54±9.54	<0.001
	Severe	32.18±11.37	
Sticky saliva	Mild	26.29±10.58	0.109
	Severe	29.98±11.71	
Coughing	Mild	23.54±9.54	<0.001
	Severe	32.18±11.37	
Felt ill	Mild	23.54±9.54	<0.001
	Severe	32.18±11.37	

Table 8: Association of mean dose of radiation to constrictor muscles with severity of symptoms at 6 mo

Symptoms		Constrictor muscles	P-value
Pain	Mild	33.71±7.39	<0.001
	Severe	51.85±9.99	
Swallowing	Mild	33.71±7.39	<0.001
	Severe	51.85±9.99	
Senses problem	Mild	36.28±10.35	<0.001
	Severe	51.37±10.32	
Speech problem	Mild	33.22±7.27	<0.001
	Severe	51.76±9.98	
Social eating	Mild	38.52±12.22	<0.001
	Severe	51.87±9.77	
Social contact	Mild	36.87±9.54	<0.001
	Severe	52.48±9.76	
Less sexuality	Mild	38.83±10.73	<0.001
	Severe	52.8±9.57	
Teeth	Mild	43.41±12.65	<0.001
	Severe	52.42±9.6	
Opening mouth	Mild	42.87±12.56	0.001
	Severe	51.5±10.36	
Dry mouth	Mild	43.41±12.65	<0.001
	Severe	52.42±9.6	
Sticky saliva	Mild	42.87±12.56	0.001
	Severe	51.5±10.36	
Coughing	Mild	43.41±12.65	<0.001
	Severe	52.42±9.6	
Felt ill	Mild	43.41±12.65	<0.001
	Severe	52.42±9.6	

In our study, the increase in mean dose to constrictor muscles leads to an increase in symptoms and hence leads to poor quality of life as observed during our study.

DISCUSSION

Radiotherapy (RT) is a highly efficacious and best treatment available for head and neck cancer, both in primary settings and as an adjuvant setting post-surgery. IMRT is a highly advanced approach to three-dimensional (3D) treatment planning and conformal therapy. IMRT still experiences a myriad of treatment-related toxicities, which can, significantly impact their QOL. Understanding the relationship between dosimetric patterns and QOL outcomes in HNC patients treated with IMRT is of paramount importance for optimizing treatment planning. Our study had comparable results with the study done by Edvard Abel *et al.* [10-13]. The study observed that some of the symptoms improved and problems faced by patients about swallowing and dysphagia increased in the follow-up period. These changes occur in the majority of our patients as Parotid glands and constrictor muscles are the major organs at risk during therapy and sometimes, because of the confluent pattern, it is difficult to save them [14, 15].

The association of the mean dose of radiation to left Parotid and right Parotid with the severity of symptoms at 6 mo depicts that in those patients where the mean dose was higher, the symptoms were in the severe category as compared to the mild ones. These observations were similar to studies done by Gupta *et al.* [12] and Ghosh *et al.* [13] in their set of patients [16, 17].

The mean dose given to constrictor muscles also correlated with the severity and quality of life as seen in our study, which was similar to the study done by radiation-induced swallowing dysfunction in patients with head and neck cancer, Yi-Hsiang Chiu *et al.*

Thus, QOL in head and neck cancer depends upon several factors that are of much importance in estimating and evaluating the outcome. The one important aspect in the life of our patients is time, which elapses post-treatment because, with time, good hygiene practices and changes made in day-to-day life lead to better rehabilitation post-cancer journey.

CONCLUSION

The study assessed the quality of life (QOL) and dosimetric analysis of patients treated with IMRT for head and neck cancer using the EORTC QLQC-30 and H and N35 scales. Evaluating 100 patients, with a 6% loss to follow-up, the study found that QOL gradually improved over time but not uniformly across all parameters. The side effects persisted, indicating that significant time is needed for noticeable changes. The study highlights the importance of elapsed time post-treatment, good hygiene practices, and day-to-day life changes inpatient rehabilitation. Constant morale upliftment and hope are crucial for patient follow-up, suggesting the need for longer study periods to better understand and enhance QOL outcomes.

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AUTHORS CONTRIBUTIONS

All the authors have contributed equally

CONFLICTS OF INTERESTS

Declared none

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