



Sequential versus Simultaneous Integrated Boost Intensity Modulated Radiotherapy in Head and Neck cancers: A Dosimetric Study

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ABSTRACT

Background:

Head and neck cancers represent a significant global health burden, contributing substantially to global cancer incidence and mortality. Management of locally advanced disease requires delivery of high radiation doses to achieve effective tumor control while limiting toxicity to surrounding critical structures. Intensity-modulated radiotherapy (IMRT) allows highly conformal dose delivery and is commonly implemented using either a sequential boost (IMRT-SEQ) or a simultaneous integrated boost (IMRT-SIB) technique. Comparative evaluation of the dosimetric performance of these approaches is essential to optimize treatment planning and improve therapeutic outcomes in this patient population.

Methods:

This prospective dosimetric study included 10 patients with histologically confirmed locally advanced squamous cell carcinoma of the oral cavity, oropharynx and hypopharynx (Stage II–IVA). For each patient, CT-based IMRT plans were generated using both sequential boost (IMRT-SEQ) and simultaneous integrated boost (IMRT-SIB) techniques. IMRT-SEQ delivered 54 Gy in 27 fractions followed by a cone-down of 6 Gy in 3 fractions and a further boost of 6 Gy in 3 fractions to a total dose of 66 Gy in 33 fractions. IMRT-SIB delivered 54 Gy at 1.8 Gy, 60 Gy at 2 Gy, and 66 Gy at 2.2 Gy per fraction simultaneously to low, intermediate and high-risk regions respectively, in 30 fractions. Dosimetric parameters including planning target volume coverage (V95, V105), conformity index, homogeneity index, and doses to organs at risk were compared between the two techniques.

Results:

Both IMRT-SEQ and IMRT-SIB achieved adequate planning target volume coverage, with V95 exceeding 95% for all PTVs. IMRT-SEQ demonstrated superior dose homogeneity, with significantly better homogeneity index values for high-dose target volumes, while IMRT-SIB showed significantly improved conformity indices, reflecting superior dose sculpting. Maximum doses to the high-dose target volume were higher with IMRT-SEQ due to cumulative dose contribution from sequential treatment phases. Dosimetric parameters for organs at risk, including spinal cord, brainstem, parotid glands, and mandible, were comparable between both techniques, with all doses maintained within accepted tolerance limits.

CONCLUSION:

Both IMRT-SEQ and IMRT-SIB are effective and dosimetrically acceptable techniques for the treatment of locally advanced oral cavity, oropharyngeal and hypopharyngeal cancers. IMRT-SEQ offers superior dose homogeneity, whereas IMRT-SIB provides improved dose conformity, shorter overall treatment time, and eliminates the need for replanning. Selection of technique should be individualized based on tumor characteristics, institutional resources, and planning expertise. Further prospective clinical studies are warranted to correlate dosimetric advantages with toxicity and oncological outcomes.

Keywords: IMRT, Sequential Boost, Simultaneous Integrated Boost, Oral cavity cancer, Oropharyngeal cancer, Dosimetric comparison

I. INTRODUCTION

Head and neck cancers constitute a major global health burden, with oral cavity and oropharyngeal malignancies accounting for nearly 890,000 new cases and 450,000 deaths annually



worldwide [1]. The incidence demonstrates marked geographic variation, with South and Southeast Asia bearing a disproportionately high burden due to widespread tobacco use, betel quid chewing, and alcohol consumption [2,3]. In India, oral cavity cancer is among the most common malignancies and frequently presents at a locally advanced stage [3,4]. In contrast, oropharyngeal cancers in Western populations have shown a rising incidence of human papillomavirus-associated tumors [5].

Radiotherapy plays a central role in the management of locally advanced oral cavity and oropharyngeal cancers, either as definitive treatment or in the adjuvant setting. Optimal locoregional control requires delivery of high radiation doses to gross tumor and nodal volumes while minimizing toxicity to adjacent critical organs such as the spinal cord, brainstem, salivary glands, and mandible [6–8].

The advent of intensity-modulated radiotherapy (IMRT) has enabled highly conformal dose delivery with improved sparing of organs at risk [6,9]. Dose escalation using IMRT can be achieved through either sequential boost (IMRT-SEQ) or simultaneous integrated boost (IMRT-SIB) techniques. While IMRT-SEQ offers superior dose homogeneity, IMRT-SIB provides improved conformity, reduced overall treatment time, and greater treatment efficiency [10–12]. Comparative dosimetric evaluation of these techniques is essential to guide evidence-based treatment planning and institutional practice.

II. METHODOLOGY

This was a descriptive dosimetric study conducted from January 2024 to December 2025, following approval from the Institutional Ethics Committee.

A total of 10 histologically proven patients with locally advanced squamous cell carcinoma of the oral cavity, oropharynx and hypopharynx (AJCC Stage II–IVB) treated with definitive chemoradiotherapy were included.

Inclusion criteria included patients aged 25–80 years of either gender, with unresectable disease or those not suitable for surgical management. Patients with prior head and neck surgery or previous radiotherapy were excluded.

Simulation and Immobilization

All patients were immobilized in the supine position using a four-clamp thermoplastic head, neck, and shoulder mask with appropriate head support. Planning CT simulation was performed using a 128-slice CT scanner with 2-mm slice thickness. The planning datasets were imported to the Eclipse Treatment Planning System (Varian Medical Systems, version 15.6.06) via DICOM protocol.

Target Volume Delineation

Target volumes and organs at risk (OARs) were contoured according to ICRU, DAHANCA, and EORTC guidelines. Gross tumor volumes for primary (GTVp) and nodal disease (GTVn) were defined based on clinical examination and imaging. Clinical target volumes were generated for high-risk (CTV66), intermediate-risk (CTV60), and elective nodal regions (CTV54). Planning target volumes (PTVs) were created by adding a uniform 5-mm margin to respective CTVs.

Treatment Planning

For each patient, two IMRT plans were generated: Sequential Boost IMRT (IMRT-SEQ) and Simultaneous Integrated Boost IMRT (IMRT-SIB).

IMRT-SIB:

PTV66 received 66 Gy (2.2 Gy/fraction), PTV60 received 60 Gy (2 Gy/fraction), and PTV54 received 54 Gy (1.8 Gy/fraction) in 30 fractions.

IMRT-SEQ:

An initial phase delivered 54 Gy in 27 fractions to elective and high-risk PTVs, followed by a boost of 6 Gy in 3 fractions to intermediate-risk PTV and a further boost of 6 Gy in 3 fractions to high-risk PTV, resulting in a total dose of 66 Gy in 33 fractions.

Dose constraints were applied as per QUANTEC recommendations. Treatment plans were optimized to ensure $\geq 95\%$ of each PTV received $\geq 95\%$ of the prescribed dose.

Dose-volume histogram (DVH) parameters were analyzed for target volumes including Dmax, Dmin, Dmean, V95%, V105%, homogeneity index (HI), and conformity index (CI). OAR dosimetry was evaluated for spinal cord, brainstem, optic structures, parotid glands, and mandible.

Statistical analysis was performed using SPSS software. Continuous variables were analyzed using paired t-tests, while non-parametric tests were applied where appropriate.

III. RESULTS

Ten patients with histologically proven locally advanced squamous cell carcinoma of the oral cavity and oropharynx were included in the study. Most patients were elderly, with 40% belonging to the 71–80 year age group, followed by 30% in the 51–60 year group, 20% in the 61–70 year group, and 10% in the 41–50 year group. Males constituted 80% of the study population, while females accounted for 20%. Tobacco exposure was the predominant etiological factor; 40% of patients reported exclusive smokeless tobacco use, 30% reported combined smoked tobacco and alcohol use, 20% reported use of smoked tobacco, smokeless tobacco, and alcohol, and 10% reported smoked tobacco alone. Among female patients, 100% reported smokeless tobacco use. Long-term addiction exceeding 20 years was



observed in a majority of tobacco and alcohol users. (Table 1)

The most common primary tumor site was the pyriform sinus, accounting for 50% of cases, followed by the tonsillar region (20%). Anterior tongue, soft palate, and vallecula each accounted for 10% of cases. Histopathological analysis revealed that 60% of tumors were moderately differentiated (Grade 2), while 30% were well differentiated (Grade

1) and 10% were poorly differentiated (Grade 3). With respect to tumor staging, 60% of patients had T2 disease, 20% had T4a disease, and 10% each had T3 and T4b disease. Nodal involvement was absent in 60% of patients, while 40% had varying degrees of nodal disease. All patients were non-metastatic. Stage II disease was observed in 40% of patients, whereas 60% presented with Stage III–IVB disease. (Table 1)

Table 1: Baseline Clinicopathological Characteristics of Patients (n = 10)

Characteristic	Category	n (%)
Age (years)	41–50	1 (10)
	51–60	3 (30)
	61–70	2 (20)
	71–80	4 (40)
Sex	Male	8 (80)
	Female	2 (20)
Addiction history	Smokeless tobacco	4 (40)
	Smoked tobacco + alcohol	3 (30)
	Smoked tobacco + smokeless tobacco + alcohol	2 (20)
	Smoked tobacco alone	1 (10)
Primary tumor site	Pyriform sinus	5 (50)
	Tonsil	2 (20)
	Anterior tongue	1 (10)
	Soft palate	1 (10)
	Vallecula	1 (10)
Histopathological grade	Well differentiated (Grade 1)	3 (30)
	Moderately differentiated (Grade 2)	6 (60)
	Poorly differentiated (Grade 3)	1 (10)
Stage grouping (AJCC 8th)	Stage II	4 (40)
	Stage III	2 (20)
	Stage IVA	2 (20)
	Stage IVB	2 (20)

Both IMRT-SEQ and IMRT-SIB achieved excellent planning target volume coverage, with more than 99% of the target volume receiving at least 95% of the prescribed dose across all dose levels. For the low-risk target volume (54 Gy), IMRT-SIB demonstrated significantly lower maximum and mean doses compared to IMRT-SEQ, while maintaining comparable minimum dose, coverage, homogeneity, and conformity. For the intermediate-

risk target volume (60 Gy), IMRT-SEQ delivered higher maximum and mean doses, whereas IMRT-SIB showed slightly increased high-dose hotspots, with overall target coverage remaining comparable. In the high-risk target volume (66 Gy), IMRT-SEQ achieved superior dose coverage parameters and higher mean dose, while both techniques demonstrated similar dose homogeneity and conformity. (Table 2)

Table 2: Comparison of Mean Dosimetric Parameters for PTVs between IMRT-SEQ and IMRT-SIB

Parameter	PTV 54		PTV 60		PTV 66	
	SEQ	SIB	SEQ	SIB	SEQ	SIB
Dmax (Gy)	69.1	60.3	69.1	66.8	68.9	68.3
Dmin (Gy)	43.0	42.4	46.1	46.9	59.6	58.7
Dmean (Gy)	59.4	54.1	63.1	60.1	66.5	65.6
V95 (%)	99.2	99.2	99.2	98.9	99.7	98.9
V105 (%)	0.4	0.4	0.2	0.8	0.0	0.0
D2% (Gy)	55.9	55.8	62.0	62.3	68.1	67.0
D98% (Gy)	52.3	52.3	58.1	57.8	64.9	63.4



D50% (Gy)	54.4	54.1	60.4	60.2	66.6	65.7
Volume (cc)	571.8	159.2	399.1	300.5	75.7	75.5
Homogeneity Index (HI)	0.06	0.06	0.06	0.07	0.04	0.05
Conformity Index (CI)	0.99	0.99	0.99	0.99	0.99	0.99

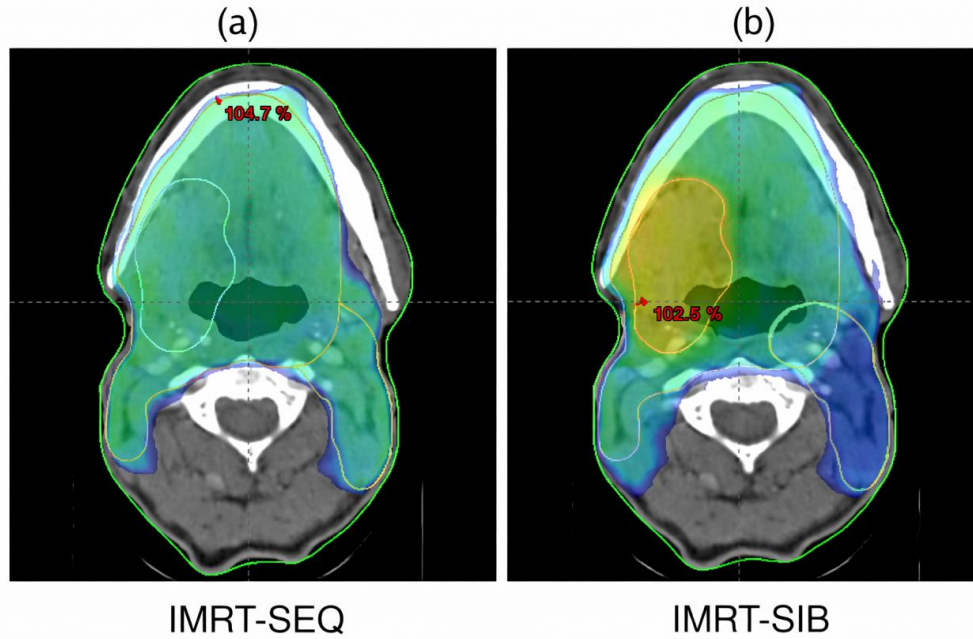


Figure 1. Representative axial CT slice showing isodose distribution for (a) IMRT-Sequential Boost and (b) IMRT-Simultaneous Integrated Boost plans.

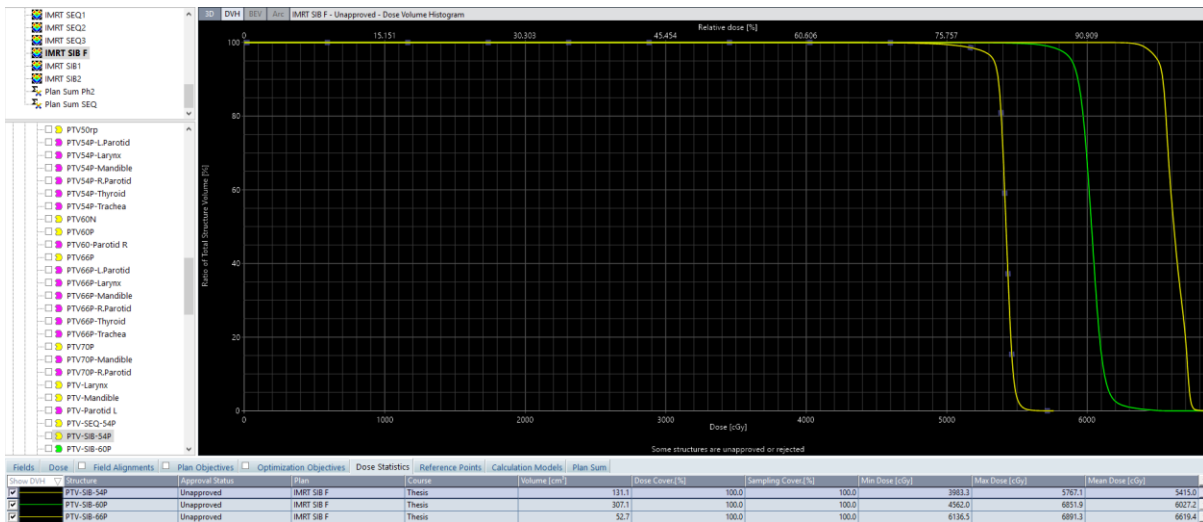


Figure 2. Cumulative dose-volume histogram (DVH) illustrating dose distribution for planning target volumes receiving 54 Gy, 60 Gy, and 66 Gy using the IMRT-Simultaneous Integrated Boost (SIB) technique.

Dosimetric analysis of organs at risk showed no statistically significant differences between the two techniques. Maximum doses to the spinal cord and brainstem remained within accepted tolerance limits. Doses to optic structures, parotid glands, and mandible were comparable, confirming effective organ-at-risk sparing with both IMRT-SEQ and IMRT-SIB. (Figure 3)

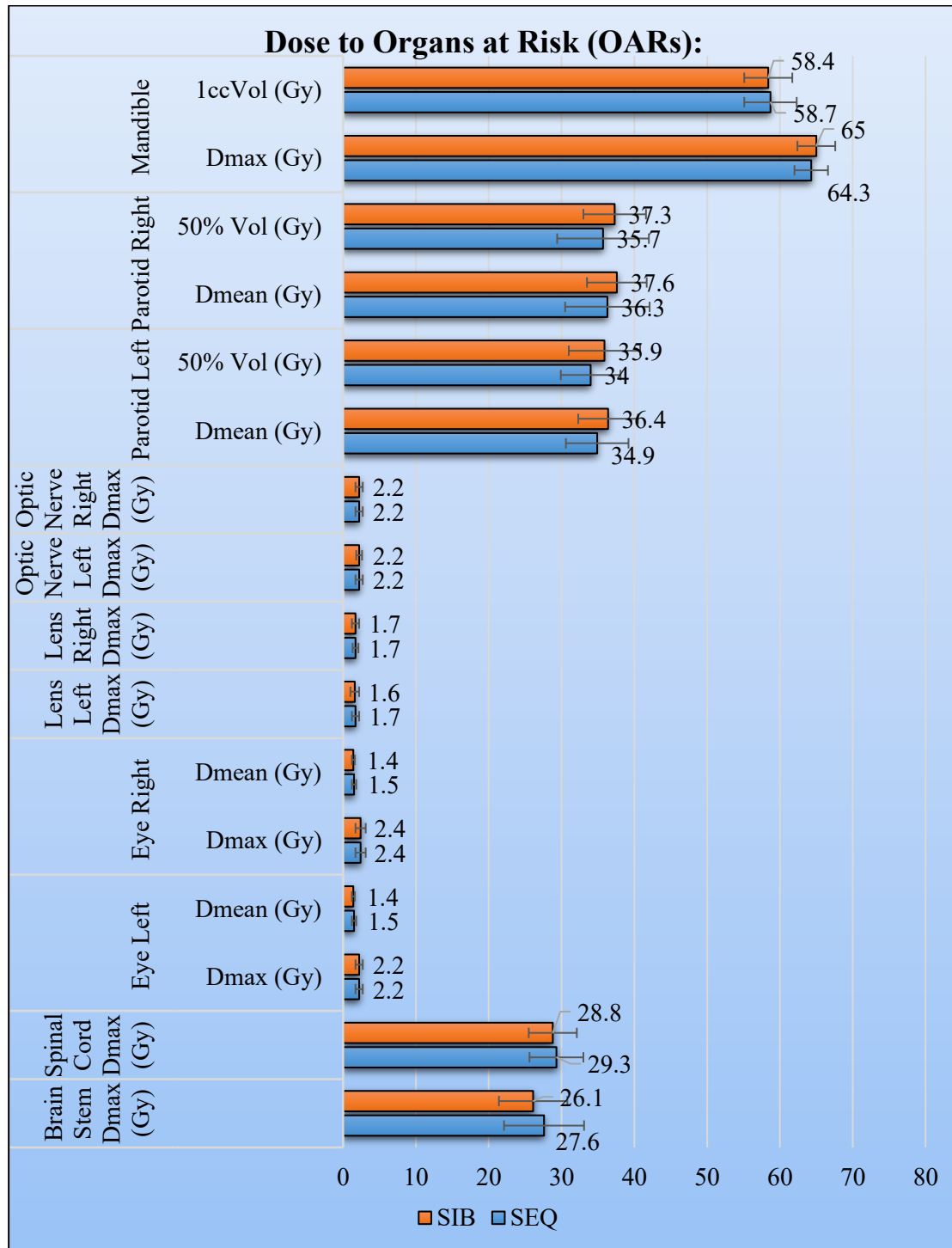


Figure 3. Bar graph depicting the comparison of dosimetric parameters for organs at risk between IMRT–Sequential Boost (SEQ) and IMRT–Simultaneous Integrated Boost (SIB) techniques, including the brainstem, spinal cord, optic apparatus, parotid glands, mandible, and lenses.

Overall, IMRT-SIB provided improved dose conformity with reduced dose spillage, whereas IMRT-SEQ demonstrated superior dose homogeneity and slightly better high-dose target coverage, with

both techniques achieving acceptable organ-at-risk dosimetry.



IV. DISCUSSION

Head and neck cancers, particularly those involving the oral cavity and oropharynx, continue to represent a major public health challenge in India, where exposure to tobacco-related carcinogens remains widespread. According to GLOBOCAN 2022 estimates, cancers of the lip and oral cavity accounted for approximately 143,759 new cases in India, representing nearly 10% of all newly diagnosed malignancies nationwide [1,4]. State-level data from the ICMR–NCDIR further highlight Maharashtra as a high-burden region, driven largely by the high prevalence of tobacco use [4]. Against this epidemiological background, optimization of radiotherapy techniques that maximize tumor control while minimizing treatment-related toxicity is of paramount importance.

The age distribution in the current study demonstrated a predominance of elderly patients, with 40% belonging to the 71–80 year age group. This finding contrasts with several Indian studies that report a median or mean age in the mid-50s [13–15]. Sathishkumar et al. reported a median age of 55 years in a large population-based analysis, while Arora et al. and Grover et al. documented mean ages around 56 years in institutional cohorts [13–15]. Population-based data by Mathur et al. have demonstrated a steep rise in head and neck cancer incidence among individuals aged 60 years and above [4]. The concentration of elderly patients underscores the need for radiotherapy techniques that maintain efficacy while minimizing toxicity, as treatment tolerance may be reduced in this age group.

A pronounced male predominance was observed, with males constituting 80% of the study population. This finding aligns closely with both Indian and international literature [14–17]. Studies by Arora et al. and Grover et al. reported male proportions exceeding 90%, while Western series and meta-analyses documented male predominance ranging from 70% to 90% [16,17]. The gender disparity is largely attributable to higher rates of tobacco and alcohol consumption among men. However, the inclusion of female patients in the present study highlights the growing burden of oral cancers among women in India, particularly related to smokeless tobacco use [3,4].

Addiction patterns observed in the present study reinforce the central role of smokeless tobacco in the etiology of oral and oropharyngeal cancers in India. Smokeless tobacco use alone accounted for a substantial proportion of cases, while combined tobacco and alcohol exposure was also common. These findings are concordant with large Indian studies and meta-analyses demonstrating strong associations between smokeless tobacco products,

including gutka and betel quid, and head and neck cancers [2,3]. The gender-specific addiction pattern observed in this study mirrors national trends and differentiates Indian epidemiology from Western populations, where smoking-related and HPV-associated oropharyngeal cancers predominate [5].

With respect to tumor site distribution, the present study demonstrated a predominance of hypopharyngeal and oropharyngeal subsites, particularly the pyriform sinus and tonsil, rather than classical oral cavity subsites. Pyriform sinus tumors accounted for 50% of cases. This differs from many Indian oral cavity–focused series but is consistent with reports by Grover et al. and Singh et al., suggesting regional variation in tumor subsite distribution [15,18]. Such variation may be influenced by differences in tobacco habits, referral patterns, and diagnostic practices. The higher proportion of hypopharyngeal and oropharyngeal tumors in the present study also has implications for radiotherapy planning, as these sites are anatomically complex and closely associated with critical organs at risk.

Histopathologically, the predominance of moderately differentiated (Grade 2) tumors in the present study is consistent with the typical presentation of locally advanced head and neck cancers and aligns with findings reported in several Indian series [15,18]. This histological profile supports the rationale for aggressive local therapy using definitive chemoradiation or high-dose radiotherapy techniques.

The TNM staging distribution revealed a notable proportion of Stage II disease, with T2N0M0 forming a substantial subset. This contrasts with many published studies that report Stage III–IV disease as the dominant presentation [14–16]. The relatively higher proportion of earlier-stage disease in the present study may reflect earlier detection, differences in inclusion criteria, or referral bias. Nevertheless, the presence of T4a and T4b tumors highlights that locally advanced primary tumors remain common, even in the absence of nodal disease, emphasizing the biological heterogeneity of head and neck cancers.

From a dosimetric perspective, the present study demonstrated that both IMRT-SEQ and IMRT-SIB achieved excellent planning target volume coverage across all dose levels, consistent with previous comparative dosimetric studies [10–12,16]. For elective target volumes receiving 54 Gy, IMRT-SEQ resulted in higher maximum and mean doses compared to IMRT-SIB, attributable to cumulative dose contribution from initial wide-field plans and subsequent boost phases, a phenomenon previously described by Vlacich et al. [16]. Despite these



differences, homogeneity and conformity indices remained within clinically acceptable ranges for both techniques.

In intermediate-risk target volumes receiving 60 Gy, IMRT-SEQ again demonstrated higher maximum and mean doses, while IMRT-SIB showed a tendency toward increased high-dose hotspots. This finding has been reported in earlier studies and reflects the competing optimization objectives inherent in simultaneous integrated boost planning, where multiple dose levels are delivered concurrently within a single plan [11,19]. These hotspots were generally limited and remained within acceptable dosimetric thresholds.

For high-risk target volumes receiving 66 Gy, IMRT-SEQ achieved superior coverage parameters, including higher D95 and D98 values, compared to IMRT-SIB. This advantage likely arises from the ability to independently optimize boost plans in sequential techniques, allowing greater focus on high-dose target coverage without compromise from elective volumes. Similar observations have been reported by Kachhwaha et al. and Vlacich et al., who highlighted improved high-dose coverage with sequential boost approaches, particularly in bulky or irregularly shaped tumors [12,16].

Dosimetric analysis of organs at risk demonstrated no statistically significant differences between IMRT-SEQ and IMRT-SIB. Maximum doses to the spinal cord and brainstem remained within accepted tolerance limits, and doses to the parotid glands and mandible were comparable between techniques. These findings are consistent with prior studies demonstrating effective organ-at-risk sparing with both techniques when modern inverse planning algorithms and QUANTEC-based dose constraints are applied [7,8,14,16].

Radiobiologically, the IMRT-SIB technique offers potential advantages by delivering a higher dose per fraction to gross disease and reducing overall treatment time, potentially counteracting accelerated tumor repopulation in squamous cell carcinomas of the head and neck [6,10]. However, these theoretical benefits must be balanced against the slightly reduced high-dose target coverage observed in some cases. Conversely, IMRT-SEQ offers a radiobiologically familiar approach with superior dose homogeneity and high-dose coverage, albeit at the cost of longer treatment duration and the need for replanning.

Overall, the differences observed between IMRT-SEQ and IMRT-SIB in the present study reflect fundamental differences in planning philosophy rather than inherent superiority of one technique over the other. Sequential boost planning allows focused optimization of boost volumes,

resulting in improved high-dose coverage, while simultaneous integrated boost enhances dose conformity and treatment efficiency. Both techniques achieve excellent target coverage and organ-at-risk sparing when appropriately planned, supporting individualized technique selection based on tumor characteristics, institutional resources, and clinical priorities, particularly in high-burden, resource-variable settings such as India.

V. CONCLUSION

This dosimetric comparison demonstrates that both IMRT-SEQ and IMRT-SIB achieve clinically acceptable planning target volume coverage and effective sparing of organs at risk in locally advanced oral cavity and oropharyngeal cancers. IMRT-SEQ provides superior high-dose target coverage and improved dose homogeneity, particularly for boost volumes, while IMRT-SIB offers better treatment efficiency through reduced overall treatment time and elimination of replanning requirements. Higher maximum and mean doses observed with IMRT-SEQ for elective and intermediate-risk volumes are attributable to cumulative dose summation inherent to sequential planning.

Despite these differences, dosimetry for critical organs at risk—including spinal cord, brainstem, parotid glands, and mandible—remained comparable between the two techniques and within accepted tolerance limits. Both IMRT-SEQ and IMRT-SIB represent valid treatment approaches, and technique selection should be individualized based on institutional resources, physics support, and patient-specific factors. Prospective clinical trials evaluating toxicity, oncological outcomes, and quality of life are required to define the optimal radiotherapy strategy for head and neck cancers.

VI. LIMITATIONS

The small sample size and single-center design of this prospective dosimetric study may limit the statistical power and generalizability of the findings. The short study duration and exclusive focus on dosimetric parameters precluded assessment of long-term clinical outcomes, toxicity profiles, and quality-of-life measures. Inclusion of heterogeneous primary tumor sites and reliance on cumulative dose summation in the sequential boost technique without adaptive or deformable image registration may have introduced dosimetric uncertainties. Nevertheless, the study provides practical, real-world insights into the dosimetric performance of IMRT-SEQ and IMRT-SIB techniques in a resource-constrained institutional setting.



REFERENCES

- [1]. Sung H, Ferlay J, Siegel RL, et al. Global cancer statistics 2020: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. *CA Cancer J Clin.* 2021;71(3):209–249.
- [2]. Gupta B, Johnson NW. Systematic review and meta-analysis of association of smokeless tobacco and head and neck cancer in India. *Int J Cancer.* 2014;135(6):1431–1443.
- [3]. IARC Working Group on the Evaluation of Carcinogenic Risks to Humans. Smokeless tobacco and some tobacco-specific N-nitrosamines. IARC Monographs on the Evaluation of Carcinogenic Risks to Humans. Vol 89. Lyon: IARC; 2007.
- [4]. Mathur P, Sathishkumar K, Chaturvedi M, et al. Cancer incidence in India: Results from population-based cancer registries. *Natl Med J India.* 2020;33(3):148–152.
- [5]. Chaturvedi AK, Engels EA, Pfeiffer RM, et al. Human papillomavirus and rising oropharyngeal cancer incidence in the United States. *J Clin Oncol.* 2011;29(32):4294–4301.
- [6]. Nutting CM, Morden JP, Harrington KJ, et al. Parotid-sparing intensity modulated versus conventional radiotherapy in head and neck cancer (PARSPORT): A phase 3 multicentre randomised controlled trial. *Lancet Oncol.* 2011;12(2):127–136.
- [7]. Bentzen SM, Constine LS, Deasy JO, et al. Quantitative analyses of normal tissue effects in the clinic (QUANTEC): An introduction to the scientific issues. *Int J Radiat Oncol Biol Phys.* 2010;76(3 Suppl):S3–S9.
- [8]. Emami B, Lyman J, Brown A, et al. Tolerance of normal tissue to therapeutic irradiation. *Int J Radiat Oncol Biol Phys.* 1991;21(1):109–122.
- [9]. Gregoire V, Mackie TR. State of the art on dose prescription, reporting, and recording in intensity-modulated radiotherapy (IMRT). *Radiother Oncol.* 2011;100(1):1–3.
- [10]. Mohan R, Wu Q, Manning M, Schmidt-Ullrich R. Radiobiological considerations in the design of fractionation schemes for intensity-modulated radiation therapy of head and neck cancers. *Radiother Oncol.* 2000;56(2):159–171.
- [11]. Miyazaki M, Nishiyama K, Ueda Y, et al. Comparison of simultaneous integrated boost and sequential boost in intensity-modulated radiotherapy for head and neck cancer. *Radiat Med.* 2008;26(3):141–147.
- [12]. Kachhwaha SS, Bhaskar S, Saini J, et al. Dosimetric comparison between sequential boost and simultaneous integrated boost intensity-modulated radiotherapy for head and neck cancers. *J Cancer Res Ther.* 2016;12(2):905–910.
- [13]. Sathishkumar K, Vinothkumar V, Badwe RA, et al. Trends in head and neck cancers in India from 1990 to 2016. *Asian Pac J Cancer Prev.* 2014;15(13):5379–5386.
- [14]. Arora N, Panda NK, Sharma SC. Dosimetric comparison of different IMRT techniques in head and neck cancer. *J Med Phys.* 2015;40(3):137–145.
- [15]. Grover S, Swisher-McClure S, Mitra N, et al. Total mucosal irradiation with intensity-modulated radiotherapy in head and neck cancer. *Radiat Oncol.* 2014;9:35.
- [16]. Vlacich G, Stavvas MJ, Poon I, et al. A dosimetric comparison between sequential boost and simultaneous integrated boost intensity-modulated radiotherapy for locally advanced head and neck cancer. *Radiother Oncol.* 2012;102(3):329–334.
- [17]. Jiang X, Wu J, Liu Y, et al. A systematic review and meta-analysis of intensity-modulated radiotherapy techniques for head and neck cancer. *Oral Oncol.* 2018;82:117–126.
- [18]. Singh MP, Kumar V, Agarwal A, et al. Epidemiology and clinicopathological profile of head and neck cancers in North India. *Indian J Cancer.* 2016;53(4):424–428.
- [19]. Stromberger C, Zwicker F, Huber PE, et al. Simultaneous integrated boost IMRT in head and neck cancer: A dosimetric comparison. *Strahlenther Onkol.* 2010;186(4):214–220.
- [20]. ICRU Report 83. Prescribing, recording, and reporting photon-beam intensity-modulated radiation therapy (IMRT). International Commission on Radiation Units and Measurements. 2010.