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A planning comparison using a body contour with a head and neck mask and a body contour without a head and neck mask in Head and neck cancer

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Running title: Mask vs. No Mask: Planning Comparison in H&N Cancer

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Abstract:

In radiation for head and neck cancer, where patient positioning is crucial, accuracy in dose estimation is critical. Although thermoplastic masks are frequently used for immobilization, it is still up for debate whether or not these devices should be added to the body contour during planning. Two planning approaches are compared in this study: one that integrates the thermoplastic mask into the body contour and the other that does not. Using an identical beam dataset in the Eclipse planning system, 22 VMAT treatment plans were created. CT datasets were replicated for each case to provide comparable designs with and without the mask contour.

In addition to standard tissue dose comparisons, dosimetric factors like D95%, D2%, and conformity index (CI) were evaluated for the PTV. The results show that target coverage and OAR sparing were marginally enhanced when the mask was removed from the body contour. These findings lend evidence to the possible benefit of removing immobilization devices from the body contour to improve treatment precision and planning effectiveness in clinical practice.

Keywords: Radiotherapy, H&N, Dosimetry, VMAT, PTV

1-Introduction

A wide range of tumors that develop in anatomical locations such as the mouth, throat, larynx, nasal passages, sinuses, and salivary glands are referred to as head and neck cancers. Squamous cell carcinoma, the most common histological subtype, develops from the epithelial lining of these areas. Sarcomas, lymphomas, and adenocarcinomas are less common variations. Depending on the location and stage of the tumor, different treatment approaches may be used, such as surgery, chemotherapy, radiation therapy, immunotherapy, or targeted biological agents. The main objective is to manage the tumor while maintaining the damaged structures' structural integrity and functionality. To reduce damage to healthy tissues, radiation administration must be precise because of the anatomical complexity and close proximity to

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vital organs. In order to improve treatment results and patient survival, early diagnosis is still crucial [1]. The implementation of Immobilization devices improves the repeatability of patient positioning in radiation for head and neck cancer. In the literature, many types of contention have been documented [2-9]. Among these, depending on their level of sophistication, thermoformed masks are employed. To make the treatment more accurate, we aim in this study to investigate the impact of the thermoplastic head and neck mask by comparing two types of treatment planning methods: a body contour including the thermoplastic head and neck mask and a body without it, through PTV coverage and OAR doses, as well as low doses. Using Eclipse TPS (Treatment Planning System) [10], a software tool used in radiation oncology to plan and optimize radiation treatment for cancer patients.

2- Materials and methods

2-1. Treatment planning algorithm

The Anisotropic Analytical Algorithm (AAA) was used to calculate doses in all treatment plans created for the current study using the Eclipse Treatment Planning System (version 16) [11]. Using a 6 MV photon beam that was delivered by the Varian Halcyon linear accelerator, a consistent beam model was used in every instance. This system is equipped with a dual-layer multi-leaf collimator (MLC), each leaf having a 1 cm width (Varian Medical Systems, Palo Alto, CA, USA). Dose distributions for 22 head and neck cancer cases that all used volumetric modulated arc treatment (VMAT) were calculated using the AAA. This configuration made it easier to assess each plan's dosimetric performance and enabled systematic comparison across all plans.

2-2. Simulation

For simulation, all patients were immobilized using a thermoplastic head and neck mask (Meicen Medical, Guangzhou, China), which was secured to an indexed base plate on the CT simulation couch to ensure reproducibility [12]. Reference marks were placed on the mask surface to assist in positioning. A 16-slice Siemens Somatom Definition AS CT scanner (Siemens Healthineers, Erlangen, Germany) was used to acquire axial images from the skull vertex to the clavicles with a slice thickness of 2 mm [13]. These images were transferred to the Eclipse treatment planning system (Varian Medical Systems, Palo Alto, CA) for target and organ-at-risk delineation [11]. Where clinically indicated, CT datasets were fused with additional imaging modalities such as magnetic resonance imaging (MRI) or positron emission tomography (PET) to aid in accurate target volume definition [14].

2-3. Target volume and organs at risk (OARs) contouring

Radiation oncologists delineated the target volume and OARs of 22 cases. The gross tumor volume (GTV) was expanded to the planning target volume (PTV). The organs at risk (OARs) that were contoured are the brainstem, optic chiasm, optic nerves, cochlea, and spinal cord. According to a radiation oncologist's guide for organs at risk and their dosage constraints (15).

2-4. Treatment planning

All of the plans utilized the VMAT technique with double arcs for full rotation (360°) with a 6 MV photon beam, starting with the first arc's counterclockwise arc [16]. The maximum dose rate was set to 600 MU/min, after which the optimization procedure automatically controlled it. The AAA was used to calculate every plan. In Eclipse treatment planning, the dose optimization employed the photon optimizer (PO) algorithm version 16. The absorbed dose in the PTV is confined within 95 % to 107 % of the prescribed absorbed dose [17].

For each of the calculated plans, a thermoplastic head and neck mask was included as a part of the body. We then duplicated the CT images and changed the body contour to exclude the mask so we could compare the two methods. Once the mask was no longer part of the body contour, any required modifications were made. In addition, the optimization was left the same; the new plan was just recalculated.

3-Results

3.1-Target volume

DVH was used to evaluate the doses between a body contour with a thermoplastic head and neck mask and a body contour without a thermoplastic head and neck mask.

The dosimetric comparisons of PTV between the two methods at D_{95}, D_2, and D_{max} for each case are shown in Table 1. The highest differences of dose at D_{95}, D_2, D_{max} were 88,64%, 102,8% and 107,3% for body contour with a thermoplastic head and neck mask method, and 93,37%, 103,8% and 110,2% for body contour without it, respectively. The dose of the body contour without a thermoplastic head and neck mask method was higher than the body contour with a thermoplastic head and neck mask method in all cases at D_{95}, $D_{2,}$ and D_{max}.

The conformity index (CI) for both dose methods is shown in Table 1 to evaluate the quality of the plan. The CI value of 1.00 represents the perfect coverage of the prescribed dose to PTV.

The CI for a body contour without a thermoplastic head and neck mask method was, to a certain extent, higher, 0.68, than the body contour with a thermoplastic head and neck mask method, 0.51, in all cases.

3.2-Normal organs

The average dosimetric comparison of a body with the thermoplastic head and neck mask method (the first method) and a body without the thermoplastic head and neck mask method (the second method) in normal organs is shown in Table 2. The maximum for the brain stem in the first method plan and the second was 37.06 and 37.54 Gy, respectively. All the same, the maximum for the spinal cord in both methods was 34.04 and 34.23 Gy, respectively. For the optic chiasm, the maximum dose (Dmax) between the first method and the second was 19.13 Gy for a body with a thermoplastic head and neck mask method, while a body without a thermoplastic head and neck mask method received a dose of 19.25 Gy.

For the normal organs, the doses were slightly less in a body contour with a thermoplastic head and neck mask method than in a body contour without a thermoplastic head and neck mask method in all organs.

3.3-Low doses

50% of the dose was comparable in all cases for both methods (Figure 1). On the other hand, low doses, such as 10 Gy coverage, decrease in a body contour without a thermoplastic head and neck mask method compared with a body contour with a thermoplastic head and neck mask method (Figure 2).

Table 1: The dosimetric comparisons of PTV between the two methods at D95, D2, and Dmax

PTV	**With a thermoplastic head and neck mask (22)**	**Without a thermoplastic head and neck mask (22)**	**Standard deviation**
D_{95}(Gy)	66,54	69,34	1,39
$V_{2\%}$	102,34	103,74	0,44
$D_{max\%}$	106,85	107,78	0,46
CI	0,51	0,68	0,008

Table 2: The average dosimetric comparison of a body with a thermoplastic head and neck mask and a body without a thermoplastic head and neck mask in normal organs

OARs	With a thermoplastic head and neck mask (22)	Without a thermoplastic head and neck mask (22)	Standard deviation
Brain stem	37,06	37,54	0,19
Spinal Cord	34,04	34,54	0,11
Optic chiasm	19,13	19,25	0,06
Right cochlear	21,76	21,96	0,11
Left cochlear	23,21	23,46	0,13
Right optic nerve	17,67	17,74	0,04
Left optic nerve	18,33	18,42	0,05
Right parotid	26,9	27,03	0,1
Left parotid	29,57	29,68	0,06
Mandible	34,83	35,18	0,08
Right eye	16,9	17,02	0,06
Left eye	16,35	16,49	0,07

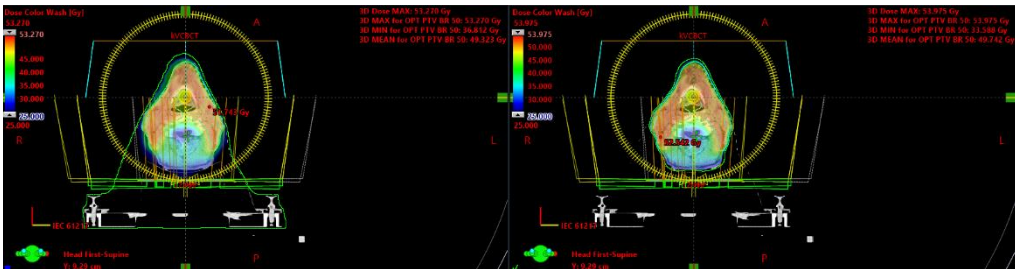

Figure 1: 50% of the dose

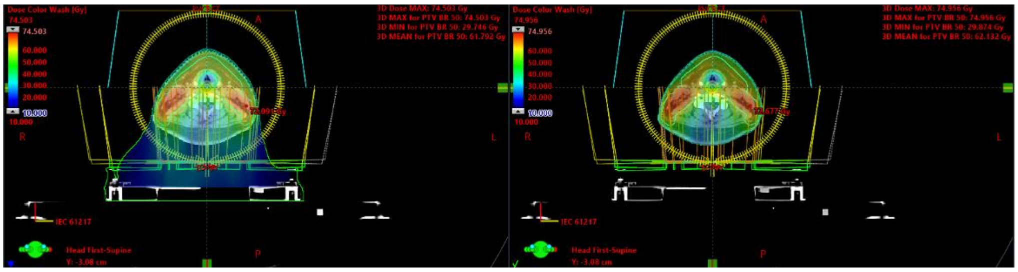

Figure 2: 10% of the dose

4-Discussion

This study evaluated two contouring procedures used to create treatment plans for head and neck cancer: one that included the thermoplastic immobilization mask in the body contour and the other that did not. Because different institutions have different procedures and there are no established guidelines, the integration of immobilization materials is still up for debate even when the VMAT techniques are the same [18]. While some centers eliminate the mask to improve productivity, others frequently use it in contouring. Additionally, mask contouring can introduce variability and take an extended period.

The results we obtained demonstrated that better dose coverage of the PTV resulted from removing the mask from the body contour. In plans without the mask, parameters like D95 and D2 showed higher values, most likely because the body contour and actual tissue density were better aligned, preventing the unnatural heterogeneities that the mask introduced. Furthermore, the absence of the mask resulted in a consistently higher conformity index (CI), indicating a more optimal dose distribution.

Regardless of the visual similarities between the two approaches, a quantitative analysis revealed significant differences. Both methods produced similar doses for organs at risk, with the inclusion of the mask resulting in an acceptable decrease, perhaps as a result of minute variations in scatter or attenuation. Overall, leaving out the mask could improve workflow and did not degrade the quality of the plan.

5-Conclusions

By using two different methods—a body contour with a thermoplastic head and neck mask, and a body contour without a thermoplastic head and neck mask. the dose was compared in the target volume (PTV) and normal tissues (OARs) for head and neck cancer. To accept the most effective methodology for daily practice, the dose coverage of the target using the body contour with a thermoplastic head and neck mask was lower (mean D95%= 66,54Gy) in average than using the body contour without a thermoplastic head and neck mask (meanD95%= 69,34Gy), as well as normal tissues (E.g. Brain stem 37,06Gy and 37,54Gy for the body contour with a thermoplastic head and neck mask and for the body contour without a thermoplastic head and neck mask respectively. It is necessary to employ evaluation criteria such as D95, D2, Dmax, and CI for target volume as well as dosage tolerance for normal tissues; nevertheless, the difference was tolerable and minimal. Considering these findings, we may avoid delineating the body contour with the thermoplastic head and neck mask, allowing faster treatment delivery without compromising treatment quality for the greater good of the patient.

Conflict of interest: NIL

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