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Analysis Of Volumetric Modulated Arc Therapy (Vmat) Radiotherapy in Cases of Tongue Cancer At Mrccc Siloam Semanggi Hospital

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Abstract:

At MRCCC Siloam Hospital, the technique for Volumetric Modulated Arc Therapy (VMAT) in tongue cancer uses fixation masks and tongue spatulas. Although the use of these fixation devices is common, further research is needed to evaluate their effectiveness more deeply and understand their impact on treatment outcomes and patient quality of life. This study uses a descriptive method with a case study approach, involving the evaluation of fixation devices, such as tongue spatulas, used to maintain patient position stability during radiation. Research shows that the use of a tongue depressor is effective in improving radiation accuracy, reducing doses to organs at risk (OAR), and clarifying the tumor area. This enhances radiation accuracy and reduces risks to healthy tissues. This makes the treatment more effective in destroying cancer cells. This research is expected to contribute to the development of standard radiotherapy procedures for tongue cancer patients, particularly in the use of VMAT techniques. The implementation of Volumetric Modulated Arc Therapy (VMAT) in the treatment of tongue cancer at MRCCC Siloam Hospital has demonstrated significant improvements in treatment accuracy and patient outcomes. The study underscores the effectiveness of fixation devices, particularly the tongue spatula, in enhancing radiation delivery while minimizing exposure to surrounding healthy tissues. These findings advocate for the routine use of VMAT and appropriate fixation techniques in clinical practice, ultimately contributing to better disease control and improved quality of life for patients with tongue cancer.

***Keywords:** Volumetric Modulated Arc Therapy (VMAT) Technique, Tongue cancer,Tongue depressor*

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INTRODUCTION

Data from the Global Cancer Observatory of the WHO indicates the 10 deadliest types of cancer worldwide. Lung cancer ranks first with 1,796,144 deaths, followed by colorectal cancer (935,173 deaths), and lastly prostate cancer (375,304 deaths). In Indonesia, lung cancer is the most prevalent type of cancer, with approximately 34,783 new cases and 30,843 deaths reported in 2020. According to data from the World Health Organization (WHO) in 2020, the number of tongue cancer cases worldwide exceeded 377,000, resulting in more than 177,000 deaths. In Indonesia, tongue cancer ranks 17th among the most prevalent cancers, with a total of 5,780 cases.

The pathology found in the tongue is tongue cancer. Tongue cancer is a malignancy classified as carcinoma that affects the tongue, with almost 95% being squamous cell carcinoma. The incidence and mortality of tongue cancer vary depending on geographic area. Geographically, India shows a high incidence rate of oral cavity cancer at 7.5 per 100,000 population, posing a significant health burden.

Tongue carcinoma is a malignant type of carcinoma that affects the tongue, with nearly 95% being squamous cell carcinoma. Most cases of tongue carcinoma occur in the anterior two-thirds of the tongue, generally along the lateral and ventral surfaces, accounting for approximately 40-75% of cases. This malignancy represents 1% of all body carcinomas and is the most commonly found malignancy in the oral cavity, accounting for 25-45%. The side effects of radiotherapy significantly influence the decline in the quality of life of patients. Research by Calcicedo et al. indicated that 65.7% of patients experienced a decline in their quality of life after undergoing 21 treatments of radiotherapy. The decline in quality of life was found after three weeks of treatment. The side effects of radiotherapy vary depending on the patient’s physical condition. Some patients may only experience mild discomfort, while others may face severe complications. Additionally, the side effects that arise are contingent upon the specific type of radiotherapy received. There are side effects that typically occur shortly after radiotherapy, which are directly experienced by patients, as well as longer-term effects that may manifest weeks or even several months after treatment.

Volumetric Modulated Arc Therapy (VMAT) is a radiation technique in which the gantry rotates 360 degrees around the tumor while the radiation remains active or in a beam-on position. The delivery of radiation doses using VMAT differs slightly from Intensity-Modulated Radiation Therapy (IMRT) in terms of gantry rotation and dose rate variability. The IMRT technique delivers radiation with a static gantry and a constant dose rate, while the VMAT technique provides radiation doses with a rotating gantry and a dose rate that changes over time. In this study, both IMRT and VMAT techniques utilized a 6 MV X-ray modality.

At MRCCC Siloam Hospital, the VMAT technique for tongue cancer radiotherapy employs fixation masks and tongue spatulas. Although the use of these fixation devices is common, further research is needed to evaluate their effectiveness more comprehensively and understand their impact on treatment outcomes and patients' quality of life. Therefore, this study aims to investigate the effect of using fixation devices, such as the tongue spatula, in radiotherapy for tongue cancer. Based on this background, the author is interested in conducting research titled "Analysis of Volumetric Modulated Arc Therapy (VMAT) Radiotherapy Examination in

Clinical Tongue Cancer at MRCCC Siloam Hospital Using Tongue Spatula Fixation Devices in Cancer Patients.".

METHODS

The type of research used is descriptive qualitative with a single primary sample focusing on tongue cancer treated with Volumetric Modulated Arc Therapy (VMAT). Data collection was conducted through observations, interviews, and documentation. This study was carried out at the Radiotherapy Department of MRCCC Siloam Semanggi Hospital during the months of July to August in the year 2024.

RESULTS AND DISCUSSION

1. **Patient History**

   The patient selected for this study is a 54-year-old female diagnosed with tongue cancer. The total prescribed dose in the Treatment Plan Report for this case of tongue cancer is 6600 cGy, administered over 33 fractions, with a dose of 200 cGy per fraction.

2. **Registration at the Radiotherapy Clinic**

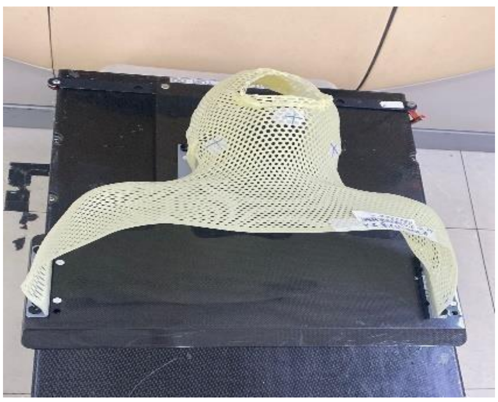
   The patient arrives at the radiotherapy administration office with a referral letter from the referring physician and other supporting documents such as Pathology Anatomy (PA) results, diagnostic CT scan results, and laboratory results. The administrative staff explains the requirements, costs of radiotherapy, and the workflow of the radiation treatment process.

3. **Consultation with the Radiation Oncology Specialist at the Radiotherapy Clinic**

   The patient visits the radiation oncology clinic, where the doctor performs an initial examination of the oral cavity since it must remain clean during radiation therapy. After evaluating the CT scan results, the radiation oncologist explains the purpose of the radiation therapy, its benefits, and potential side effects. The patient then signs a consent form for the radiotherapy procedure. The radiation oncologist plans to use Volumetric Modulated Arc Therapy (VMAT) with 6 MV energy, administering a total dose of 6600 cGy over 33 fractions, with 200 cGy per fraction.

4. **CT Simulation**

   The radiation therapist prepares the fixation tools used during the simulation for radiation, including a base plate for the head and neck, a fixation pillow, head and neck masks, a tongue spatula, micropore tape, and a blue marker.



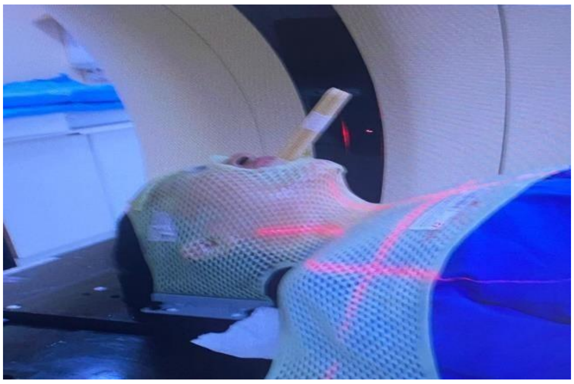
Picture 1. Mask

Picture 2. Base Plate

The therapist calls the patient, confirming her name and date of birth, and instructs her to remove any metal objects from the head and neck area. The patient is positioned head first and supine on the CT Simulator table, with the head aligned perpendicular to the fixation pillow, the body straight, and the arms by the sides.

The therapist then heats the mask in a water bath for approximately 3 minutes and prepares the head and neck mask and tongue spatula to be used for fixation. This setup aims to keep the tongue stable and prevent the palate from touching the tongue. The patient is instructed to open her mouth and bite the wooden tongue spatula, after which a mark is made on the spatula where her bite is located. The head and neck mask, soaked in the water bath, is then placed on the patient. The radiation therapist determines the reference point and moving laser at the symphysis menti and marks it using the blue marker provided with micropore tape.

Picture 3. To Spatel



Picture 4. Patient Positioning in the CT Simulator

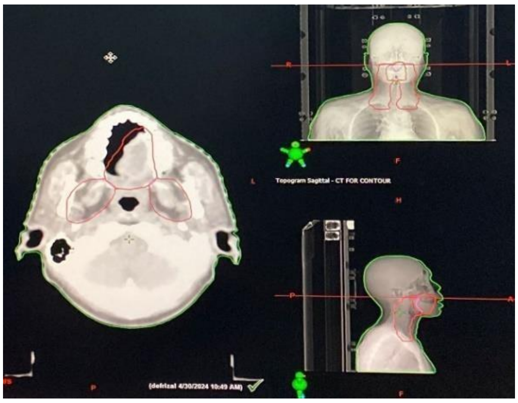
The radiation therapist performs the scanning at the operator console, creating a topogram with the upper boundary at the vertex and the lower boundary at the apex of the lungs, setting the slice thickness to 3 mm. After the scanning is completed, the data is sent to the Treatment Planning System (TPS) via DICOM. Once the simulation is finished, the patient is allowed to go home and is informed of the scheduled date for the first radiation treatment.

Picture 5. **CT Simulation Results**

The CT scan for tongue cancer is performed with an axial view, using 140 kV and 250 mAs. The sample consists of a patient with tongue cancer undergoing VMAT radiotherapy treatment.

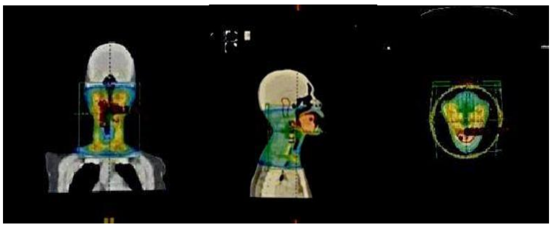
5. **Treatment Planning System (TPS)**

The procedure in the TPS room for radiation planning is conducted by medical physicists and radiation oncologists. The physician outlines (contours) the target organs and organs at risk (OAR), which is a critical part of the planning process. The oncologist requires about 2 hours to contour in tongue cancer cases due to the numerous OARs involved, and attention must be paid to the GTV, CTV, and PTV. The OARs for tongue cancer include the parotid gland, eyes, spinal cord, brainstem, mandible, cochlea, oral mucosa, pharyngeal muscles, and larynx.



Picture 6. Physician Contouring

The contouring performed by the physician is then continued by the medical physicist, who inputs data regarding the beam, including techniques used, monitor units (MU), dose rates, field size, energy (6 MV photon), collimator angles, gantry angles, isocenter beams, and the total dose of 6600 cGy over 33 fractions. This data is reflected in the Treatment Plan Report for the patient available in the radiation therapy status document. The radiation therapy plan created by the medical physicist employs the inverse planning method, followed by dose distribution calculations for the radiation target organs and OARs. The computer performs the dose calculations according to the prescribed doses for the target organs and OARs. Once the planning is completed, a review is conducted, and the physician approves the plan created by the medical physicist. Approval is required before implementing the planning on the patient in the LINAC machine room. The approved plan is signed by the medical physicist and then double-checked by another medical physicist. After that, the physician responsible also approves and signs the planning. Finally, the data is sent to the LINAC from the ARIA computer program for setup during radiation therapy.



Picture 7. Treatment Planning System (TPS) Results

Table 1. Statistical Report Based on Dose-Volume Histogram (DVH)

StrucTure	Volu me cm^3	Min dose cGy	Max dose cGy	Mea n dose cGy	Mod al dose cGy	Medi an dose cGy	Std dev cGy	Coverage(% / %)
SpinalCo rd	13,6	800.3	3980.4	3352.1	3609.8	3534.0	589.3	100.0/99.8
Mandible	59.2	2138.9	6967.5	4713.2	3744.3	4646.7	947.5	100.0/100.0

Parotid	17.7	890.7	6409.4	2781.7	1388.5	1946.9	1771.2	100.0/99.9
Eye	8,6	89,3	305.0	156.7	128.0	147.2	44.1	100.0/100.0

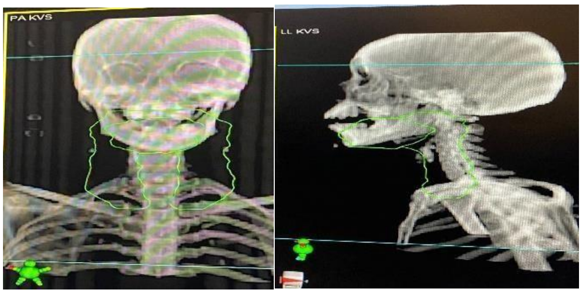
Table 2. Information on Radiation Beam Files

Field ID	Technique	MLC	Energy	Gantry(deg)	Coll(deg)	Couch(deg)	MU
PA KVS	STATIC- 1		6MV	181.0	0.0	0.0	
LL KVS	STATIC- 1		6MV	91.0	0.0	0.0	
CBCT	STATIC- 1		6MV	00	0.0	0.0	
RA1	STATIC- 1	VMAT	6MV	181.0 CW 179.0	30.0	0.0	279
RA2	STATIC- 1	VMAT	6MV	179.0 CW 181.0	330.0	0.0	300

6. Verification

Verification is performed before radiation treatment begins in the LINAC machine room for tongue cancer patients using the Volumetric Modulated Arc Therapy (VMAT) technique. With RapidArc technology, the treatment duration is significantly shorter, as the radiation delivery occurs while the gantry rotates, preventing changes in patient positioning. The radiation delivery is shaped according to the organs being irradiated. The VMAT technique can be seen as an improvement over traditional IMRT techniques.

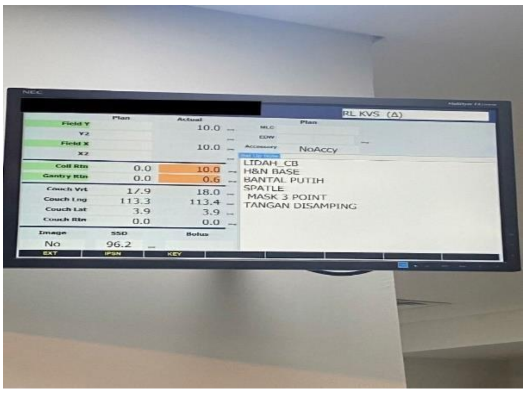
Before radiation delivery, the radiation therapist prepares the setup according to the patient's identity. The patient enters the LINAC room and assumes the same position as during the CT simulation. The radiation therapist instructs the patient to lie supine on the examination table, open her mouth, and bite the tongue spatula to protect the organs at risk in the tongue area, specifically the palate. The head and neck mask is then applied to minimize patient movement.The radiation therapist adjusts the examination table according to the reference points marked on the patient's mask based on the lasers present in the LINAC room, which serve as the initial reference for field shifts or isocenter beam points determined by the medical physicist. If the reference points are correctly aligned, the medical physicist calculates the necessary shifts for the examination table as indicated on the Isocenter Verification sheet. The radiation therapist then makes the necessary longitudinal, vertical, and lateral adjustments to the table. Various tools are available for geometric verification, including Electronic Portal Imaging Devices (EPID), Onboard Imaging Devices (OBI), and Cone Beam Computed Tomography (CBCT). The radiation therapist performs verification using the Onboard Imager (OBI) to check for treatment delivery errors and ensure the patient's position aligns with the planned radiation treatment, visualized in 2D images, AP and lateral views for tongue cancer using the VMAT technique. Daily verification using OBI results in clearer images due to the use of kV energy, making it easier to align the images with the radiation planning with greater precision. The tolerance limit for position shifts during radiation verification is set at 3 mm from the reference point. Daily verification is conducted to ensure that the dose received by the patient targets the tumor accurately while protecting the surrounding organs at risk, with verification performed for each fraction of treatment.



Picture 8. Verivication obi

7. Radiation Delivery in the LINAC Room

The radiation therapist administers the radiation treatment with the prescribed dose delivered to the patient using the LINAC machine. The dose received by the target aligns with the planning created by the medical physicist, which is sent from the TPS to the LINAC machine. The radiation treatment using the VMAT technique for tongue cancer requires approximately 5 minutes of irradiation with two gantry rotations. During the first rotation, the gantry and MLC rotate around the patient from angles 170° to 320°, and in the second rotation, they rotate back from 320° to 170°. During dose distribution, the gantry rotates, and the MLC moves dynamically to conform to the shape of the tumor.



Picture 9. Monitor in the LINAC Room

Picture 10. Patient positioning

Picture 11. LINAC

Use of the Tongue Spatula and Analysis of Target Dose Volume and OAR in VMAT for Tongue Cancer Cases

The spatula is used in tongue cancer radiation treatment to stabilize the tongue, preventing movement and separating the palate from the tongue area. This ensures that the radiation beam accurately targets the designated area without damaging surrounding healthy tissues. By pressing down on the tongue, the spatula also clarifies the tumor area, enhancing radiation accuracy and reducing risks to healthy tissue. This makes treatment more effective in destroying cancer cells.

Table 2 shows the DVH statistical report indicating OAR doses, where the spinal cord has a volume of 13.6 cm^3 and receives a dose of <50 Gy, specifically 39.80 Gy. The parotid gland receives a minimum dose of 89.07 Gy, with a mean dose of 27.81 Gy, which remains below the parotid gland's threshold mean dose of <25 Gy. The maximum dose received by the eye is <45 Gy, with a maximum dose of 30.50 Gy during this radiation treatment. Additionally, the mandible also remains below the dose limit, with the maximum dose received being <70 Gy, specifically 69.67 Gy during this treatment session.

CONCLUSIONS

Based on the researcher's observations of tongue cancer cases using the VMAT technique, it can be concluded that the management of radiotherapy is carried out through several stages, including: consultation with a Radiation Oncology Specialist, performing CT simulation, and sending the CT simulation results to the

Treatment Planning System (TPS) for planning and dose calculation conducted by the physician and medical physicist. After the Radiation Oncology Specialist signs the dose calculation form, all data from the TPS is sent to the linear accelerator (linac) via the ARIA computer program for data setup prior to radiation therapy. On the scheduled day of irradiation, a geometric verification will be conducted first, followed by the radiation therapy process in the linac room.

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