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Commissioning of Virtual Simulation and its Role in the Treatment Planning of Head and Neck Cancers at Charlotte Maxeke Johannesburg Academic Hospital (CMJAH)

Bronwin P Van Wyk[1], Leo P Masamba[2], Vinay Sharma[2] and Thulani Nyathi[1]

[1]*Department of Radiation Sciences, Division of Medical Physics, Charlotte Maxeke Johannesburg Academic Hospital, South Africa*
[2]*Division of Radiotherapy, Charlotte Maxeke Johannesburg Academic Hospital, South Africa*

Abstract

The objective of this paper was to share the experience of virtual simulation commissioning and its use in radiation therapy of head and neck cancers at Charlotte Maxeke Johannesburg Academic hospital. The first sixty three (63) head and neck cases planned on the virtual simulation station was analyzed as well as the impression of staff members after using the system. A semi structured survey revealed that staff was overall satisfied with the system. A follow-up study with more cases planned, however, is advised.

Keywords: Head and neck cancer; Radiotherapy; Treatment; Immobilisation

Introduction

Head and neck cancers are one of the most troublesome cancer groups, with 60% of them presenting at locally advanced stages and local regional recurrence constituting the predominant recurrent pattern [1]. Radiotherapy is a standard non-surgical therapy for locally advanced head and neck cancers, which form approximately 10% of all 3000 cancer cases treated at our hospital, where 80% of these cases presenting in advanced stages. As per cancer reports, head and neck cancer formed approximately 4% of all cancer cases treated in South Africa in the year 1998 and 1999 [2-4].

Radiotherapy for head and neck cancer aims to administer high doses to target volumes whilst sparing critical structures like mucous membranes, spinal-cords and parotid glands; hence increasing chances of cure and rEduccing acute and long term complications to the patient. Dental reviews are vital before the irradiation of head and neck tumours, to prevent tooth decay and risk of subsequent bone necrosis. Treatment planning is an essential component for radiation therapy, especially in curative treatments where doses up to 70 Gy may be delivered to the primary site. Simulation "mimics" the actual radiation treatment and therefore forms an integral part of the treatment planning of head and neck cancers [5-8]. Different types of radiotherapy treatment planning include: hand planning by means of a single patient contour, two-dimensional (2D) planning by means of bony-land marks on a conventional simulator, and three dimensional (3D) planning by means of computed tomography (CT) which provides information not only about target.

Volumes but about critical (normal) organs as well. Virtual simulation is a multidimensional planning technique based on CT images, which "provides the user with an accurate reproduction of anatomical features from the viewpoint of the treatment source" [9-12]. The virtual simulation workstation at CMJAH does not incorporate a 3D dose algorithm (cannot calculate dose and optimise a plan) and thus described as two and half -dimensional (2.5D) planning at our centre.

Since CMJAH is an academic hospital; virtual simulation was introduced for teaching and training purposes and to "relief" the workload on the conventional simulator and consequently rEduccing our patient waiting list since a new modality of treatment was introduced/available.

At our facility the two dimensional treatment technique decided upon in treating some head and neck cases are two lateral parallel opposed multi leaf collimated (MLC) fields (instead of alloy shields). This meant that all treatment fields having these MLC shields had to be uploaded manually on the treatment machine, at our facility. With the introduction of virtual simulation, these fields could be transferred automatically, which prevented uploading them after hours, hence saving time.

Virtual simulation as used "conventionally"-with a computed tomography (CT) scanner and console, virtual simulation workstation, and moveable lasers; is not applied at our facility. Our CT-scanner does not have movable lasers, and it is separated/in a different room from the Virtual simulation workstation. The virtual simulation workflow, as demonstrated in Figure 1, has remained the same as other treatment techniques in our department, this was done to keep familiarity. Head and neck cases are immobilised using individualised perspex shells (masks) to prevent patient movement during treatment and to ensure accurate reproducibility in the treatment set-up. An in-house manufactured "head and neck immobilisation system" (that was designed to incorporate the head rest and mask of the patient, and keep patient shoulders out of the field of treatment) as demonstrated in Figures 2 and 3, is also used for immobilisation. Patients are scanned and planned using the Shift method - this method does not necessitate a physician to be available for the CT scan. After the scan is done the images are transferred to the virtual simulation system, physicians then place their treatment fields on the system, without contouring the target volumes. Similar to what happens on a conventional simulator, but with an added advantage of having a three dimensional CT image

***Corresponding author:** Bronwin P Van Wyk, Department of Radiation Sciences, Division of Medical Physics, Charlotte Maxeke Johannesburg Academic Hospital, South Africa, Tel: +27125214771; E-mail: bronwin.vanwyk@smu.ac.za

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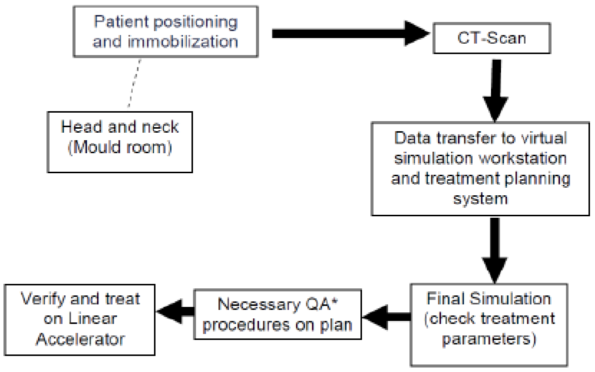

Figure 1: CMJAH virtual simulation workflow. *Second check field size, monitor units, LANTIS entry, etc.

Figure 2: Head and neck immobilisation.

to plan on. Shifts (superiorly or inferiorly, laterally and anteriorly or posteriorly) from the reference marks on the CT scanner and the treatment iso center are then calculated based on the treatment plan. On the first day of treatment, the patient is positioned to the initial reference marks and then shifted to the treatment isocenter using the calculated shifts. The components used for Virtual Simulation at our facility is demonstrated in Table 1.

As witnessed in Table 1 and Figure 1 our department uses a conventional simulator in the process of treating "virtually" (treating using computer-based treatment simulation), as oppose to acquiring moveable lasers driven under computer control.

Methodology

The first 63 cases planned on the system were analyzed. The data collected was not separated into male and female, as this would not have added any value to this study. Also there was no inclusion/exclusion criteria used for this study. The head and neck cancer cases that were planned using virtual simulation were radical (curative intent) for doses up to 66 and 70 Gy. The treatment technique used was two lateral and two offcord fields, a matching anterior neck field, and two posterior neck electron fields.

The CT and positioning protocol used for virtual simulated head and neck cases is given in Table 2. The survey was conducted by means of a semi structured interview. Six radiation oncologist and eight radiotherapists participated in the survey and the following questions were asked of them [11]:

- Is there a role for virtual simulation at CMJAH?
- What are the "negatives" of the technique/workflow?
- What are the "positives" of the technique/workflow?
- What is your overall impression of the virtual simulation technique as used at
- CMJAH?

Results and Discussion

An initial audit on the types of head and neck cases treated using virtual simulation was done after its introduction and is demonstrated in Figure 4. There are a number of advantages associated with the virtual simulation technique as chosen to be used at our department. The time the patient spends on the CT-scanner as compared to conventional simulation is less, since we have a multi-sliced CT scanner and adopted

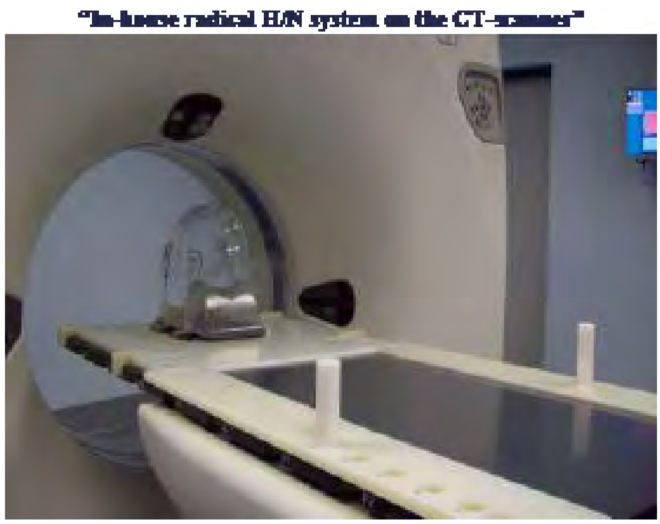

Figure 3: Head and neck immobilisation.

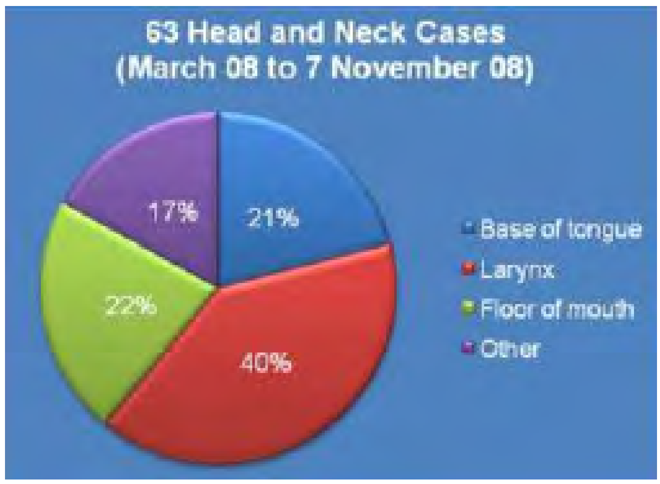

Figure 4: The initial 63 head and neck cases treated using virtual simulation.

Conventional simulator	CT-scanner	Virtual simulation station	Planning system
Toshiba KXO-50M	General Electric MX165 ZJ HSG	General Electric Advantage Workstation 4.3	Helax_TMS 6.1B
Radiography/Fluoroscopy	Target material W/Rh	RTP link** CT, MRI, TPS	RTP link** CT, VS, MRI, PET
Output 50 kW	Minimum slice width 3 mm	Displays beam geometries in 3D	Quality Assurance Tools
Tube Voltage 40-150 kV	Maximum Voltage 140 kV	Displays internal anatomy in 3D	One of the 'first' full 3D planning system
Tube Current 10-630 mA	Maximum Current 350 mA	"User friendly"***	"User friendly"***
SAD* 80/100 cm	Gantry aperture 70 cm	Facilitates design of treatment portals with blocks and multileaf collimators	Both Collapsed cone and pencil beam algorithms

*Source to axis/treatment distance; **Radiotherapy link to Computed Tomography (CT); Magnetic Resonance Imaging (MRI); Treatment Planning System (TPS); Virtual Simulation (VS) and Positron Emission Tomography (PET); ***Dependent on staff expertise

Table 1: Virtual simulation components at CMJAH.

Site	Immobilization	Patient positioning	Scan protocol	Slice thickness	Scan Limit
H/N*	Perspex Mask ± Tongue depressor Head rest ± Bite block Radical H/N* board	Supine	Head and Neck	0.5 cm	Vertex to below supra sternal notch

*Head and neck

Table 2: Treatment protocols for Virtual Simulated cases at CMJAH.

the shift-method. All data is transferred electronically, which eliminates them being uploaded manually on the treatment machine. The 3D view of the image assist the physicians in the location of the tumour and the beam arrangement desired with the added advantage of measuring the post electron field depths for individual patients which assists in choosing the appropriate electron energy.

The disadvantages of virtual simulation are the cost implications associated with the system, and the fact that the field shaping is time intensive for physicians especially if not use to the workstation.

The survey revealed that the majority of oncologists (five out of six) and radiotherapists (six out of eight) demonstrated positive attitudes with regard to the use of virtual simulation at our facility. However the radiation oncologists highlighted the disadvantage of the shift method - the inability to modify slice thickness, head position of the patient they would prefer, etc. after the scan is taken by the radiotherapist; and the radiotherapists thought the use of the conventional simulator in the treatment technique of virtual simulation was additional work.

Conclusion

Virtual simulation as a technique of radiotherapy treatment planning was successfully commissioned and has become acceptable to the users at CMJAH. It is clear that the data amassed is not large, but this study can definitely be a follow up study; with more cases analyzed and more staff members interviewed.

Author's Contribution

The first two authors contributed equally to this work.

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