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

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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 reducing 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 tends to incorporate 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 topography (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 reducing 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 moveable 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.

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of a semi-structured interview. Six radiation oncologists 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 to plan on. Shifts (superiorly or inferiorly, laterally and anteriorly or posteriorly) from the reference marks on the CT scanner and the treatment isocenter 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 opposed 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 off-cord 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
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.

References

5. Course CSR Sasa Mutic. MS Mallinckrodt Institute of Radiology, Washington University School of Medicine St. Louis, MO 63110, USA.

Table 1: Virtual simulation components at CMJAH.

<table>
<thead>
<tr>
<th>Site</th>
<th>Immobilization</th>
<th>Patient positioning</th>
<th>Scan protocol</th>
<th>Slice thickness</th>
<th>Scan Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>H/N</td>
<td>Perspex Mask ± Tongue depressor  Head rest ± Bite block  Radical H/N ‘board</td>
<td>Supine</td>
<td>Head and Neck</td>
<td>0.5 cm</td>
<td>Vertex to below supra sternal notch</td>
</tr>
</tbody>
</table>

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