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Original Research Paper

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TREATMENT DELIVERY TIME OF INTENSITY MODULATED RADIOTHERAPY BY A HALCYON 2.0 SYSTEM

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ABSTRACT **Introduction:** The radiotherapy treatment can deliver with better accuracy if treatment time can reduced. The Halcyon system was designed in such a way that it can easily increase the clinical workflow as per manufacturer (Varian Medical Systems) recommendations. Few works studied and tested the actual delivery efficiency of the Halcyon system. This work analysed the treatment time on a Halcyon 2.0 unit for various treatment sites along a period of one year. **Materials and Methods:** In radiotherapy, treatment time includes patient setup, image acquisition, image-guidance in online then couch correction and radiation delivery time. The required data were extracted from the ARIA oncology information system and were studied as a function of the treatment site, the delivery modality, and the time from the first day of treatments with the Halcyon 2.0 system in the Carcinova cancer hospital. **Results:** A total of 2900 fractions of 100 patients were delivered during the analysed period (all are IMRT plans) for the period of one year. The number of fractions by site ranged from 1500 fractions for head and neck, 750 fractions for two sites (lung and breast) and 650 fractions for cervix and rectum. After a week adaptation period of the staff, the daily mean treatment time was reduced to 8.5 min. **Conclusions:** The Halcyon 2.0 ring gantry shaped linear accelerator allowed delivering online intensity radiation therapy in all fractions with total treatment time consistently below the 10 minutes standard time slot, for most of the studied treatment sites.

KEYWORDS : Halcyon, VMAT, IMRT, Treatment Time

INTRODUCTION

The treatment fraction delivery time is a key indicator of the external beam radiotherapy process. The ring gantry shaped Halcyon (medical linear accelerator) system was designed to improve the clinical workflow, according to the manufacturer (Varian Medical Systems) recommendations.

Shorter treatment time reduce the inaccuracy and magnitude of intra-fractional motion, [1] and also improve patient comfort [2]. However, the knowledge of treatment time in a clinical setting is essential to optimize the patient scheduling, by adapting the duration of the treatment slots to the actual time needed for the treatment. An obvious advantage of an optimized scheduling is the increase of the medical linear accelerator patient throughput, [3] with contributes to reduce the costs of radiotherapy implementation [4].Few works studied and analysed that the actual delivery efficiency of the Halcyon system. This work analysed the treatment time on a Halcyon 2.0 unit for a variety of sites along a period of one year.

MATERIALS AND METHODS

In radiotherapy setup, Treatment time included patient setup, image acquisition, and image-guided then online couch correction and radiation treatment delivery time. Data were extracted from the ARIA oncology information system and were studied from the second-generation Halcyon 2.0 was introduced in July 2018 [5]. According to the manufacturer, the system was designed to improve the clinical workflow, allowing efficient online intensity modulated radiotherapy (IMRT) and volumetric arc therapy (VMAT) techniques. Halcyon uses a 6 MV flattening-filter-free beam for treatment, and a novel dual-layer stacked–staggered multileaf collimator [6,7]. The leaves reach a maximum speed of 5.0 cm/sec.

In the Halcyon 1.0, the field modulation was performed by the lower layer only, while the upper acted just as a backup. In the Halcyon 2.0 both layers modulate the beam, thus allowing more complex fluences to be delivered. In the Halcyon 1.0, the available image modalities included orthogonal MV pairs and megavoltage cone-beam CT (CBCT). The Halcyon 2.0 also introduced kilo-voltage cone-beam CT capability. An image acquisition is mandatory in the Halcyon system prior to each treatment fraction. The gantry rotational speeds reach 4 rpm/min for CBCT acquisition, and 2 rpm/min for VMAT delivery. Hence, a full-rotation CBCT may be acquired in 15 s, while a full VMAT arc can be delivered in 30 s. Halcyon results up to four and two times faster for the imaging and delivery steps than a True Beam linac. Moreover, the Halcyon workflow was designed to streamline the manual operations needed for patient setup, imaging, and treatment delivery.

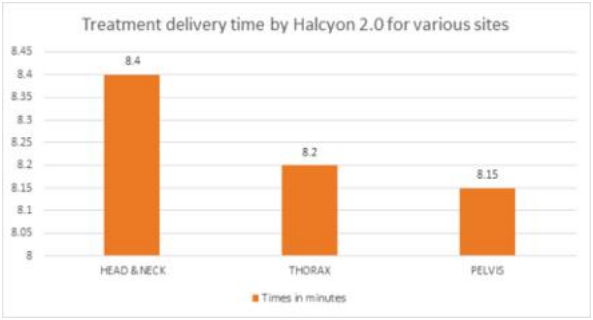
The Halcyon 2.0 linac console is linked to the ARIA 15.6 Oncology Information System (OIS) (Varian Medical Systems). In the ARIA system, to perform a treatment fraction an appointment needs to be created previously in the scheduling module of the system. Then, to deliver the fraction, the approved treatment plan is loaded (opened) in the linac console by the radiotherapy technologist (RTT). Once the treatment fraction is delivered, the RTT closes the plan in the console, and the total time for whole treatment delivery process will be recorded in ARIA.

In this work we analysed the time duration of treatment fractions delivered on the Halcyon 2.0 unit installed and

commissioned at the Carcinova Cancer Hospital, Cuttack, and Odisha, India which was the first Halcyon system for clinical use in eastern part of India. The analysis included the fractions delivered along a period of about one year and for head and neck, thorax and pelvis treatment sites with dose 2 Gray per fraction.

Table: 01 (Treatment Delivery Time by Halcyon 2.0 for Various Treated Sites)

Treatment site	Dose (GY)	Mean time for treatment delivery (min.)	Over all time for complete treatment (min.)
Head and Neck	2.0	5.40	8.40
Thorax	2.0	5.20	8.20
Pelvis	2.0	5.15	8.15



RESULTS

A total of 2900 treatment fractions corresponding to 100 patients were delivered with the Halcyon 2.0 system during the analysed period. All fractions used intensity-modulated techniques to IMRT field to field plans. As per tabulated data in table: 01 and graphical representation, the mean time for whole treatment delivery including imaging for head and neck site 5.40 (min.) and another 3.0 minutes taken for patient setup and release for all sites. Some times for low general status patients another one more minute is required for complete the process.

DISCUSSION

The treatment time of all the fractions delivered in a Halcyon 2.0 during a period of one year was analysed. The mean treatment time of all the fractions resulted to be 8.5 ± 1.0 min. Treatment time for the 100% of the fractions analysed in this work was below the standard time slot of 12 min conventionally used for C-arm linacs [4,8,9]. This conventional 12-min slot reported in the literature did not generally include image-guidance procedures in all fractions. However, in Halcyon image guidance is included for all fractions delivery.

CONCLUSIONS

The Halcyon 2.0 allows delivering online image-guided radiation therapy in all fractions with a total treatment time consistently below the 12-min standard time slot, for most of the analysed treatment sites. One of the advantages of the Halcyon platform is that the gantry rotation speed is four times that of the Truebeam linac. This potentially enables plans to be delivered in a much shorter time and therefore increases efficiency and patient throughput. The Halcyon treatment delivery system's newly designed dual-layer MLC is capable of generating IMRT plans of similar quality despite having thicker MLC leaves. Thicker MLC leaves provided stronger mechanical construction, which resulted faster MLC movement speed. The delivery speed of all treatment plans using Halcyon platform were nearly twice as faster than the true beam MLC for both fixed gantry beam arrangement (IMRT mode) and VMAT mode.

The Halcyon 2.0 ring gantry shaped linear accelerator allowed delivering online intensity radiation therapy in all fractions with total treatment time consistently below the 10 minutes standard time slot in our centre including image guidance, for most of the studied treatment sites.

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