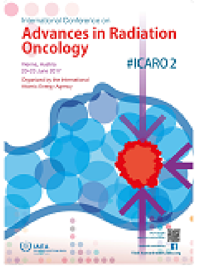

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Characterization of a Cobalt-60 radiotherapy unit upgrade: BEST Theratronics T780C to Equinox100

Wednesday, 21 June 2017 10:40 (5 minutes)

Introduction:

We have been investigating Cobalt-60 (Co60) based radiation treatment for some time through measurements on a Theratron 780C (T780C) Co60 teletherapy unit (Best Theratronics, Kanata, ON, Canada) installed at the Cancer Centre of Southeastern Ontario. Purpose built equipment was added to the unit to emulate serial tomotherapy dose delivery and enable imaging with electronic portal imaging devices. The research was complemented by Monte Carlo simulations. Results clearly indicated that modern radiation delivery is achievable using a Co60 source.

In the past year our T780C unit has been upgraded by Best Theratronics to an Equinox External Beam Therapy System (Equinox100). This is the first full upgrade of an existing T780C unit into an advanced computerised Co60 unit (see Figure 1). The upgraded unit has an increased source-to-axis distance of 100 cm (previously 80 cm), new beam collimation and motion control, a motorized 60° wedge, and a new Avanza Patient Positioning Table (couch). The Equinox upgrade allows the unit to be equipped with a DICOM-RT compatible multi-leaf collimator (MLC), which is being incorporated into the unit. The MLC will enhance the unit's three dimensional conformal radiotherapy capabilities and provide the potential for intensity modulated dose deliveries on the unit. At installation, the upgraded unit passed all acceptance tests specified by Best Theratronics for a new Equinox100 unit. In this paper we present the results of further commissioning tests performed to assess the upgraded unit's readiness for clinical use.

Methods:

The commissioning of the upgraded Equinox100 unit closely followed the process and procedures used for clinical linear accelerators at our centre. Steps included testing of mechanical and radiation beam/dosimetric parameters of the system critical to accurate treatment delivery. Mechanical testing included evaluation of the accuracy of optical distance and field size indicators along with couch position and gantry, collimator, and couch angle readouts. Couch deflection was measured with a distributed load of 75 kg. Comparisons of gantry, collimator and couch mechanical and radiation isocentres were performed using EBT3 Gafchromic film (Ashland Specialty Ingredients, Bridgewater, NJ, USA). Radiochromic film was also used to evaluate the coincidence of radiation and light fields.

Percent depth dose for different field sizes and in-plane and cross-plane dose profiles at multiple depths were measured using an ion chamber in a Blue Phantom2 water tank (IBA Dosimetry GmbH, Schwarzenbruck, Germany). Dose profiles were also recorded with the 60° wedge in place. Relative dose factors (RDF) were determined at depths of 0.5 cm and 5 cm. All measurements were repeated for the relevant range of square fields (3x3 cm2 to 40x40 cm2). Additional data is being acquired to commission the unit in the Eclipse external beam treatment planning system (Varian Medical Systems, Palo Alto, CA, USA).

Results:

Optical Distance Indicator (ODI) readings were in agreement with mechanical measurements within tolerances of 1mm at 80 cm and 100 cm and 4 mm at 120 cm. Field size readouts were found to be accurate to within 1 mm for all field sizes. Light and radiation fields were found to be coincident within 2 mm for 5x5, 10x10 and 20x20 cm2 fields. At all positions, couch, collimator and gantry angle readouts were found to be accurate within 0.5°. Couch positioning was accurate to within 1 mm over a range of ±20 cm from isocentre in all three directions. A distributed load of 75 kg produced a maximum couch deflection of 8 mm. Radiochromic film measurements showed radiation isocentre sizes of 0.23 mm, 0.44 mm and 0.05 mm for the gantry, collimator and couch systems, respectively. Radiation isocentre, indicated by starshot film measurements, to mechanical isocentre distances were measured as 0.56 mm, 0.70 mm and 0.19 mm for the gantry, collimator and couch systems, respectively. Measured percent depth dose curves showed good agreement with reference data published in the British Journal of Radiology Supplement 25. RDFs compared to the output at depth of maximum dose (0.5 cm) of a 10x10 cm2 field measured for the upgraded Equinox100 varied by less than 0.75% from the RDFs of the pre-upgrade T780C unit.

Conclusions:

All tests indicate that performance from the upgraded T780C unit was equivalent to that expected from a newly installed Equinox100 unit. In all mechanical testing the upgraded Equinox100 met or exceeded the manufacturer's acceptance testing tolerances. Dosimetric measurement results show that the beam is identical to Co60 units referenced in medical physics literature as well as the pre-upgrade T780C unit. This confirms the expected advantage of Co60 radiation therapy: units have consistent well established radiation delivery properties. Current work is underway to extend measurements to MLC defined radiation beams on the Equinox100, incorporating and validating the upgraded Equinox100 in our Monte Carlo modelling, and evaluating various commercial treatment planning systems.

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