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Dosimetric verification of intensity modulated radiation therapy

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DOSIMETRIC VERIFICATION OF INTENSITY MODULATED RADIATION THERAPY

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Certification

I, Alison Chapman, declare that this thesis, submitted in fulfilment of the requirements for the award of Master of Science - Research, in the Department of Engineering Physics, University of Wollongong, is wholly my own work unless otherwise referenced or acknowledged. The document has not been submitted for qualifications at any other academic institution.

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Abstract

Intensity modulated radiation therapy (IMRT) is a relatively new treatment planning and delivery technique. The complex multiple-segment nature of an IMRT plan makes it difficult to verify using traditional look-up tables and hand calculations.

The purpose of this project was to develop an effective and time-efficient plan checking procedure using a combination of ionisation chambers and film. The dosimeters available were 0.03 cc volume and 0.6 cc volume thimble ionisation chambers, Kodak X-Omat V (XV) film and Kodak Extended Dose Range (EDR2) film. First the dosimeters were tested for accuracy in terms of their dose response in the clinical range required (up to about 200 cGy). All were found to be suitable for further investigation for use in IMRT plan checking.

One non-IMRT and six IMRT plans were validated. The plans were transferred from the patient geometry to a 30 cm x 30 cm x 30 cm cubic phantom made up of slabs of solid water. The ionisation chambers and films were calibrated and used to measure the dose delivered to the phantom at the isocentre for each beam and for an entire IMRT treatment. The film was also used to provide axial and planar dose distribution maps for comparison with the predicted distributions. Time restraints meant that not every type of dosimeter was used for every beam and treatment plan.

It was found that the isocentric 0.6 cc volume ionisation chamber provided a suitably accurate dose check, with an average difference between predicted and measured full treatment doses of 2.0 cGy with a standard deviation of 2.7 cGy and 1.5% with a standard deviation of 2.1%. The film was less successful, with the EDR2 film (digitised and analysed using ImageJ software) giving an average difference between predicted and measured full treatment doses of 5.4 cGy with a standard deviation of 4.0 cGy and 4.0%

with a standard deviation of 3.1%. The film was very useful for obtaining qualitative dose distribution maps, which could be used as surrogates to verify that the radiotherapy treatment planning system's co-ordinate information was being transferred correctly.

Following the results of the test cases a procedure was established for all future IMRT plans. The procedure can easily be varied to include further measurements if necessary, and consists of measuring the dose at isocentre from each beam and the whole treatment using the 0.6 cc ionisation chamber. EDR2 film is to be used to visually verify the axial dose distribution, and XV film to verify planar dose distributions for each beam.

Contents

List of Figures

List of Tables

Abbreviations

%dd - percentage depth dose

3DRTP - three dimensional radiation treatment planning

3DCRTP - three dimensional conformal radiation treatment planning

AAPM - American Association of Physicists in Medicine

AHTAC - Australian Health Technology Advisory Committee

AP - anteroposterior

BEV - beam's eye view

CT - computed tomography

dMLC - dynamic multileaf collimator

DVH - dose volume histogram

EDR2 - Kodak Extended Dose Range [film]

FF - field factor

Gy - gray

IAEA - International Atomic Energy Agency

ICCC - Illawarra Cancer Care Centre

ICRU - International Commission on Radiation Units and Measurements

IMRT - intensity modulated radiation therapy

MLC - multileaf collimator

MU - monitor unit

OD - optical density

PA – posteroanterior

QA - quality assurance

relOD - relative optical density

ROI - region of interest

SAD - source-to-axis distance

SSD - source-to-surface distance

STF - step test film

TLD - thermoluminescent dosimeter

WHO - World Health Organisation

XV - Kodak X-Omat V [film]

Z - atomic number