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Verification of an independent monitor unit calculation program for IMRT quality assurance

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VERIFICATION OF AN INDEPENDENT MONITOR UNIT CALCULATION PROGRAM FOR IMRT QUALITY ASSURANCE

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Certification

I, Michael Peter Currie, declare that this thesis, submitted in partial 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.

Michael Peter Currie
16/02/07

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Abbreviations

ρ – density

AAPM – American Association of Physicists in Medicine

BCF – block correction factor

BF – boundary factor

CF – calibration factor

CT – computed tomography

D_{max} – maximum dose, typically on central axis

d_{max} – depth of maximum dose on central axis

DVH – dose volume histogram

FTP – file transfer protocol

Gy – Gray

IAEA – International Atomic Energy Agency

ICCC – Illawarra Cancer Care Centre

ICF – inhomogeneity correction factor

IMRT – intensity modulated radiation therapy

ISF – inverse square law factor

Linac – linear accelerator

MCI – modified Clarkson integral

MF – Mayneord factor

MLC – multileaf collimator

MU – monitor units

NSW – New South Wales

OAD – off axis distance

OAR – off axis ratio

PDD – percentage depth dose

POCR – primary off centre ratio

QA – quality assurance

RFO – radiation field offset

SAD – source to axis distance

S_c – collimator scatter factor

SCD – source to calibration point distance

SMR – scatter maximum ratio

S_p – phantom scatter factor

SSD – source to surface distance

SSDF – SSD factor

TERMA – total energy release per unit mass

TMR – tissue maximum ratio

TPR – tissue phantom ratio

TPS – treatment planning system

Abstract

Independent monitor unit (MU) calculations are a vital part of radiotherapy treatment planning quality assurance. In the case of complex treatment planning methods, such as intensity modulated radiotherapy (IMRT), traditional independent monitor unit calculations using tables of beam data and manual calculations are inadequate. Recently, computer programs have been developed that can perform independent monitor unit calculations for IMRT treatment plans using scatter summation methods. One such program is RadCalc, produced by Lifeline Software Inc. The purpose of this project was to test RadCalc, and determine whether it is suitable for routine use in IMRT treatment planning quality assurance.

Once the software was installed, beam data measured on the treatment linear accelerator (linac) was imported into RadCalc, to be used in MU calculations. RadCalc was tested for data integrity to ensure that the correct data was accessed for its calculations. The interface between RadCalc and the treatment planning system, Pinnacle^3, was set up so that treatment plan data could be imported directly from Pinnacle^3 into RadCalc. Test plans were imported into RadCalc to ensure the Pinnacle^3-RadCalc interface was working correctly.

Test plans were created with open, blocked, segmented and IMRT fields, and delivered to a phantom on the linac to test RadCalc's block correction algorithm. Doses were measured using a thimble ionisation chamber, and compared to the doses calculated by RadCalc and Pinnacle^3. The agreement between RadCalc and measured doses for most situations was comparable to the agreement between Pinnacle^3 and measured doses. However, a systematic difference between RadCalc and measured dose was shown to occur for asymmetric fields. In addition to this, an increase in the level of blocking of the calculation point for segmented and IMRT fields appeared to increase the difference between RadCalc and measured dose.

Thirty-two patient IMRT plans at the Illawarra Cancer Care Centre (ICCC) were verified by reproducing the plan using a phantom CT dataset, and then delivering the fields to the phantom and measuring the delivered dose. This data was compared to the doses calculated by RadCalc and Pinnacle^3. The doses calculated by RadCalc and

Pinnacle^3 for the plans created on patient CT datasets were also compared. In analysing the data, a systematic difference between RadCalc and measured dose was detected. Improved agreement was achieved by adjusting the MLC transmission parameter in RadCalc. The average percentage difference per field for the phantom plans between RadCalc and measured dose was 0.1% with a standard deviation 5.3%, while the average percentage difference between Pinnacle^3 and measured dose was -0.2% with a standard deviation of 4.2%. The average percentage difference for total plan dose for the phantom plans between RadCalc and measured dose was 0.0% with a standard deviation 1.7%, while the average percentage difference between Pinnacle^3 and measured dose was -0.3% with a standard deviation of 1.1%. For the patient plans, the average percentage difference per field between RadCalc and Pinnacle^3 was 0.8% with a standard deviation of 5.6%, while the average percentage difference per plan was 1.1% with a standard deviation of 1.1%.

The final recommendation is that RadCalc is accurate enough for routine IMRT treatment planning quality assurance. A physical measurement should accompany the RadCalc check to verify the transfer of data to the record and verify system and the dose delivery process.