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

Michael Peter Currie
University of Wollongong

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

A thesis submitted in fulfilment of the requirements for the award of the degree

Master of Science - Research

from

UNIVERSITY OF WOLLONGONG

by

Michael Peter Currie, B Med Rad Phys (Honours)

Department of Engineering Physics

2007

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, Pinnacle³, was set up so that treatment plan data could be imported directly from Pinnacle³ into RadCalc. Test plans were imported into RadCalc to ensure the Pinnacle³-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 Pinnacle³. The agreement between RadCalc and measured doses for most situations was comparable to the agreement between Pinnacle³ 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 Pinnacle³. The doses calculated by RadCalc and

Pinnacle³ 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 Pinnacle³ 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 Pinnacle³ 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 Pinnacle³ 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.