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RESEARCH ARTICLE

MEASUREMENT OF EFFECT OF DEFORMITY IN DOSE CALCULATION BY TREATMENT PLANNING SYSTEM USING GAFCHROMIC FILM

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ABSTRACT

Purpose: Accuracy in dose prediction of dose calculation algorithms is very important aspect in external beam radiation therapy. This study investigates the effect of deformity on dose calculations computed by treatment planning system.
Methods: A phantom (30x30x30 cm^3) containing rectangular solid water blocks with gafchromic film and two 5cm air gaps was used for central axis dose calculations computed by collapsed cone convolution superposition algorithm (CCCS) and Pencil Beam Convolution algorithm (PBC) in Oncentra Dynamic Environment treatment planning system. Phantom is scanned by computed tomography scanner and the image data set is transferred to the planning workstation. Depth dose measurements were taken using a gafchromic for identical beam parameters and monitor units as in the depth dose computations. The calculated and the measured percent depth dose (PDDs) were then compared. The data presented in this study included 6MV photon beam and field sizes of 3x3 cm^2, 5x5 cm^2, 10x10 cm^2 and 15x15 cm^2.
Results: The x ray beams traversed through the different media and interact as per the densities of the inhomogeneous material and deposits dose. The collapsed cone convolution superposition were within ±1.2% in the first water medium. However, upon traversing the first air gap and re entering the water medium, in comparision to the measurement s, the CCCS under predicted the dose , with difference ranged from -1.3% to -3.2% for 3x3 cm^2, from -2.3% to -4.3% for 5x5 cm^2, from -2.2% to -6.9% for 10x10 cm^2 and -1.4% to -6.5% for 15x15 cm^2.After the second air gap, the CCS continued to under predict the dose , and the difference ranged from -3.1% to -3.8% for 3x3 cm^2, from -2.3% to -5.7% for 5x5 cm^2, from -2.3% to -6.3% for 10x10 cm^2, and from -1.5% to -5.7% for 15x15 cm^2.
Conclusion: The CCCS under predicted the dose in water medium after the photon beam traversed the air gap region.

INTRODUCTION

In conventional radiation therapy treatment planning systems (TPS), photon dose calculation algorithms typically report the absorbed dose as dose to water (D_w). Dose calculation algorithms employed in the TPS aim to best match the computed results with the measurements, which are performed in water phantoms. In recent years, there has been significant interest in using dose calculation algorithms that are based on Monte Carlo (MC) approach, which can report the absorbed dose in dose to medium (D_m) mode. In the D_m mode, the absorbed dose is computed to the medium contained in the dose voxel of the material. Siebers *et al*[1] suggested that the conversion of D_m to D_w may be desirable in some of the situations when MC based calculations are used in external beam photon radiation therapy. Currently, dosimetric calibration protocols of external beam photon radiation therapy[2,3] are based on D_w mode, and the use of either D_m or D_w for MC based photon dose calculations remains a debating topics.[4]

Many authors have conducted the evaluation of dose calculation algorithms for external beam radiation therapy.[5-16] Rana *et al* investigated the dose prediction accuracy of Acuros XB algorithm and anisotropic analytical algorithm (AAA) for different field sizes and air gap thickness. The results from that study revealed that dose prediction errors are upto 3.8% for

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Acuros XB and upto 10.9% for AAA could occur during radiation therapy treatment. Furthermore, the study by Rana *et al* demonstrated the limitation of dose calculation algorithms when treating a smaller size of tumor, especially when large air gaps are created by immobilization devices. In our study we will study the dose prediction accuracy of collapsed cone and Pencil beam algorithm in case of deformed skull by Oncentra dynamic Planning Environment treatment planning system version 4.1 (Elekta, Stockholm, Sweden). The analysis of prediction accuracy was done by comparing the point doses at different depths for both CCC and PBC algorithms.

METHODS AND MATERIALS

This study utilizes a 6 Megavoltage (MV) X-ray beam from Siemens Oncor Impression Plus medical linear accelerator (Siemens, Germany). For all dose computation and measurements, the source to axis distance (SAD) setup was used. The CCC superposition model uses an algorithm in which dose is computed from first principles, thereby accounting for patient heterogeneity and other modifiers.[17] This is done by modelling the energy fluence of the beam exiting the gantry head, computation of the total energy released per unit mass (TERMA) in the tissue volume, superposing the TERMA with an energy kernel, and accounting for electron contamination which is then added to the photon dose.[17-19]

Measurement and calculation

The phantom is scanned using the CT scanner and the data is transferred to the treatment planning system using digital imaging communication in medicine (DICOM) network. An inhomogeneous phantom (30x30x30 cm^3) composed of rectangular solid water blocks and two 5 cm air gaps was manufactured and scanned using Siemens Somatom CT scanner (Siemens Medical Solutions USA, Inc., Malvern, PA). The 3D structure set was created using the oncentra treatment planning system. The central axis depth dose calculations were then performed using CCCS for open field sizes 3x3 cm^2, 5x5 cm^2, 10x10 cm^2, and 15x15 cm^2, and for 100 monitor units (MUs). The dose calculation grid size was kept 3mm for the calculation purposes.

In water medium of inhomogeneous phantom at different depths the measurement was performed using gafchromic film for identical beam parameters and same number of monitor units (MUs) was fired in all the cases for the measurement purposes. The measurements at each depth were repeated three times. The calculated and measured depth doses were then compared. The difference between percentage depth dose (PDD) were computed by CCCS with the measured value using the equation mentioned below:

$\Delta\ (PDD_d) = (CCCS\text{-}MEAS/MEAS)\ X100$

Where, PDD_d= percent depth dose at depth, d; CCCS= collapsed cone convolution superposition; MEAS= measurement value.

RESULTS

The measured PDDs and calculated PDDs are presented for field sizes 3x3 cm^2, 5x5 cm^2, 10x10 cm^2 and 15x15 cm^2.

First Water Medium

In the first water medium, the CCCS predicted the PDD within ±1.5% of of measured PDD. The highest dose prediction error (-1.5%) was obtained for the smallest test field size i.e. 3x3 cm^2.

Second Water Medium

In the second water medium (i.e. after the first air gap), the CCCS under predicted the PDD at all four depths for all four test field sizes. Specifically, dose prediction errors ranged from -1.5% to -3.2% for 3x3 cm^2, from -2.3% to -4.3% for 5x5 cm^2, from -2.2% to -6.9% for 10x10 cm^2 and -1.4% to -6.5% for 15x15 cm^2.

Third Water Medium

In the third water medium, the CCCS continued to under predict the PDDs at all depths for all test field sizes. Specifically, dose prediction errors ranged from -3.3% to -3.8% for 3x3 cm^2, from -2.4% to -5.5% for 5x5 cm^2, from -2.2% to -6.2% for 10x10 cm^2, and from -1.4% to -5.6% for 15x15 cm^2.

DISCUSSION

Dose calculation accuracy of CCCS has been evaluated by comparing the calculated and measured PDD at multiple depths in an inhomogeneous slab phantom containing two air gaps. Although the CCCS had good agreement with the measurement in the first water medium, the results showed the limitation of CCCS in predicting doses in second water medium (i.e. after the first air gap) as well as in the third water medium (i.e. after the second air gap). As the photon traverses the air gap, loss of lateral scatter increases within the air gap, and this caused decreased scatter dose contribution to the points along the central beam axis. Furthermore, media of different density can cause the electronic disequilibrium at and near their heterogeneity interface.[20-27] Thus, dose discrepancies seen in the water media after the air gaps may be due to improper beam modelling within CCCS.

CONCLUSION

The results of this study showed that the CCCS under predicted the depth doses in water medium after the photon beam traversed the air gaps. In actual clinical situation there may be high density material such as bone and low density material like muscle and air gaps into the patient which may further decreased the dose calculation accuracy. Special attention must be given during the patient setup since large air gap between the patient body and immobilization device may further lead to unacceptable dose errors. Precise beam modelling and accurate HU value in every clinical situation is playing a vital role.

Conflict of interest

The authors declare that they have no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

References

1. Siebers JV, Keall PJ, Nahum AE, Mohan R. Converting absorbed dose to medium to absorbed dose to water for Monte Carlo based photon beam dose calculations. Phy Med Biol 2000; 45:983-95.
2. Almond PR, *et al*. AAPM's TG-51 protocol for clinical reference dosimetry of high energy photon and electron beams. Med Phys 1999; 26 1847-70.
3. Huq MS, Andreo P, Song H, Comparision of the IAEA TRS-398 and AAPM TG-51 absorbed dose to water protocols in the dosimetry of high energy photon and electron beams. Phy Med Biol 2001; 46 2985-3006.
4. Keall P, Liu H, Dm rather than Dw should be used in Monte Carlo treatment planning. Med Phys 2002; 29: 922-4.
5. Rana S, Rogers K. Dosimetric evaluation of Acuros XB dose calculation algorithm with measurements in predicting doses beyond different air gap thickness for smaller and larger field sizes. J Med Phy 2013; 38: 9-14.
6. Das IJ, Ding GX, Ahnesjo A. Small fields: Non equilibrium radiation dosimetry. Med Phys 2008; 35: 206-15.
7. Gray A, Oliver LD, Johnston PN. The accuracy of the pencil beam convolution and anisotropic analytical algorithms in predicting the dose effects due to attenuation from immobilization devices and larger air gaps. Med Phys 2009; 36: 3181-3191.
8. Robinson D. Inhomogeneity correction and the analytical anisotropic algorithm. J Appl Clin Med Phys 2008; 9:2786.
9. Han T, Mourtada F, Kisling K, Mikell J, Followill D, Howell R. Experimental validation of deterministic Acuros XB algorithm for IMRT and VMAT dose calculations with the Radiological Physics Centre's head and neck phantom. Med Phys 2012; 39: 2193-2202.
10. Krieger T, Sauer OA. Monte Carlo-versus pencil beam-/-collapsed cone dose calculation in a heterogeneous multi layer phantom. Phy Med Biol 2005: 50:859-68.
11. Mackie TR, Scrimger JW, Battista JJ. A convolution method of calculating dose for 15 MV X rays. Med Phys 1985; 12:188-96.
12. Van Esch A, Tillikainen L, Pyykkonen, *et al*. Testing of the analytical anisotropic algorithm for photon dose calculation. Med Phys 2006; 33: 4130-48.
13. Ding W, Johnston P, Wong T, *et al*. Investigation of photon beam models in heterogeneous media of modern radiotherapy. Australas Phys Eng Sci Med2004; 27:39-48.
14. Dobler B, Walter C, Knopf A, Fabri D, Loeschel R, Polednik M, Schneider F, Wenz F, Lohr F. Optimization of extracranial stereotactic radiation therapy of small lung lesions using accurate dose calculation algorithms. Radiat Oncol 2006; 1:45.
15. Carrasco P, Jornet N, Duch M *et al*. Comparision of dose calculation algorithms in phantoms with lung equivalent heterogeneities under conditions of lateral electronic disequilibrium. Med Phys 2004; 31:2899-2911.
16. Rana S, Rogers K, Lee T, Reed D, Biggs C. Verification and Dosimetric Impact of Acuros XB Algorithm for Stereotactic Body Radiation Therapy (SBRT) and Rapid Arc Planning for Non Small cell Lung Cancer (NSCLC) Patients. Int J Med Phys Clin Eng Rad Onc 2013; 2: 6-14.
17. Ahensjo A. Collapsed cone convolution of radiant energy for photon dose calculation in heterogeneous media. Med Phys 1989; 16:577-92
18. McNutt T. Dose calculations: Collapsed cone convolution superposition and delta pixel beam.2002:4535 983 02474.
19. Stephen Oyewale. Dose prediction accuracy of collapsed cone convolution superposition algorithm in a multi-layer inhomogeneous phantom. Int J Cancer Ther Oncol 2013; 1(1):01016.
20. Fogliata A, Nicolini G, Clivio A, *et al*. Dosimetric evaluation of Acuros XB Advanced Dose Calculation algorithm in heterogeneous media. Radiat Oncol 2011: 6:82.
21. Hasenbalg F, Neuenschwander H, Mini R, Born EJ. Collapsed cone convolution and analytical anisotropic algorithm dose calculations compared to VMC++ Monte Carlo simulations in clinical cases. Phys Med Biol 2007; 52:3679-91.
22. Aarup LR, Nahum AE, Zacharatou C, Juhler-Nottrup T, Knoos T, Nystrom H, Specht L, Wieslander E, Korreman SS. The effect of different lung densities on the accuracy of various radiotherapy dose calculation methods: implications for tumour coverage. Radiother Oncol 2009; 91:405-14.
23. Webb S, Parker RP. A Monte Carlo study of the interaction of external beam X-radiation with inhomogeneous media. Phys Med Biol 1978; 23:1043-59.
24. McNutt T. The ADAC Pinnacle Collapsed Cone Convolution Superposition Dose Model. ADAC Radiation Therapy Products.
25. Nilsson M and Knoss T. Application of the Fano theorem in inhomogeneous media using a convolution algorithm. Phys Med Biol 1992; 37:69-83.
26. Sharpe MB, Battista JJ. Dose calculations using convolution and superposition principles: the orientation of dose spread kernels in divergent x-ray beams. Med Phys 1993; 20:1685-94.
27. Mohan R, Chui C, Lidofsky L. Different pencil beam dose computation model for photon beams. Med Phys 1986; 13:64-73.

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