UNIVERSITY
OF WOLLONGONG
AUSTRALIA

University of Wollongong
Research Online

Faculty of Engineering and Information Sciences - Papers: Part A

Faculty of Engineering and Information Sciences

2015

Is a quasi-3D dosimeter better than a 2D dosimeter for Tomotherapy delivery quality assurance?

Aitang Xing
Liverpool and Macarthur Cancer Therapy Centres

Shrikant Deshpande
University of Wollongong, sd110@uowmail.edu.au

Sankar Arumugam
Liverpool and Macarthur Cancer Therapy Centres

Armia George
Liverpool and Macarthur Cancer Therapy Centres

Lois C. Holloway
University of Wollongong, loish@uow.edu.au

See next page for additional authors

Publication Details

Xing, A., Deshpande, S., Arumugam, S., George, A., Holloway, L., Vial, P. & Goozee, G. (2015). Is a quasi-3D dosimeter better than a 2D dosimeter for Tomotherapy delivery quality assurance?. Journal of Physics: Conference Series, 573 1-4.

Research Online is the open access institutional repository for the University of Wollongong. For further information contact the UOW Library: research-pubs@uow.edu.au

Is a quasi-3D dosimeter better than a 2D dosimeter for Tomotherapy delivery quality assurance?

Abstract
Delivery quality assurance (DQA) has been performed for each Tomotherapy patient either using ArcCHECK or MatriXX Evolution in our clinic since 2012. ArcCHECK is a quasi-3D dosimeter whereas MatriXX is a 2D detector. A review of DQA results was performed for all patients in the last three years, a total of 221 DQA plans. These DQA plans came from 215 patients with a variety of treatment sites including head-neck, pelvis, and chest wall. The acceptable Gamma pass rate in our clinic is over 95% using 3mm and 3% of maximum planned dose with 10% dose threshold. The mean value and standard deviation of Gamma pass rates were 98.2% +/- 1.98(1SD) for MatriXX and 98.5%+/- 1.88 (1SD) for ArcCHECK. A paired t-test was also performed for the groups of patients whose DQA was performed with both the ArcCHECK and MatriXX. No statistical dependence was found in terms of the Gamma pass rate for ArcCHECK and MatriXX. The considered 3D and 2D dosimeters have achieved similar results in performing routine patient-specific DQA for patients treated on a TomoTherapy unit.

Keywords
2d, tomotherapy, delivery, quality, than, assurance, quasi, better, 3d, dosimeter

Disciplines
Engineering | Science and Technology Studies

Publication Details
Xing, A., Deshpande, S., Arumugam, S., George, A., Holloway, L., Vial, P. & Goozee, G. (2015). Is a quasi-3D dosimeter better than a 2D dosimeter for Tomotherapy delivery quality assurance?. Journal of Physics: Conference Series, 573 1-4.

Authors
Aitang Xing, Shrikant Deshpande, Sankar Arumugam, Armia George, Lois C. Holloway, Philip J. Vial, and Gary Goozee

This journal article is available at Research Online: http://ro.uow.edu.au/eispapers/4440

IOPscience iopscience.iop.org

Home Search Collections Journals About Contact us My IOPscience

Is a quasi-3D dosimeter better than a 2D dosimeter for Tomotherapy delivery quality assurance?

This content has been downloaded from IOPscience. Please scroll down to see the full text.

2015 J. Phys.: Conf. Ser. 573 012077

(http://iopscience.iop.org/1742-6596/573/1/012077)

View the table of contents for this issue, or go to the journal homepage for more

Download details:

IP Address: 130.130.37.85
This content was downloaded on 11/09/2015 at 05:37

Please note that terms and conditions apply.

Is a quasi-3D dosimeter better than a 2D dosimeter for Tomotherapy delivery quality assurance?

Aitang Xing[1], Shrikant Deshpande[1,3], Sankar Arumugam[1], Armia George[1], Lois Holloway[1,2,3,4], Philip Vial[1,2] and Gary Goozee[1,4]
[1]Liverpool and Macarthur Cancer Therapy Centres and Ingham Institute, Liverpool Hospital, New South Wales, Australia
[2]Institute of Medical Physics, School of Physics, University of Sydney, New South Wales, Australia
[3]Centre for Medical Radiation Physics, University of Wollongong, New South Wales, Australia
[4]South West Clinical School, University of New South Wales, New South Wales, Australia

E-mail: aitang.xing@sswahs.nsw.gov.au

Abstract. Delivery quality assurance (DQA) has been performed for each Tomotherapy patient either using ArcCHECK or MatriXX Evolution in our clinic since 2012. ArcCHECK is a quasi-3D dosimeter whereas MatriXX is a 2D detector. A review of DQA results was performed for all patients in the last three years, a total of 221 DQA plans. These DQA plans came from 215 patients with a variety of treatment sites including head-neck, pelvis, and chest wall. The acceptable Gamma pass rate in our clinic is over 95% using 3mm and 3% of maximum planned dose with 10% dose threshold. The mean value and standard deviation of Gamma pass rates were 98.2% ± 1.98(1SD) for MatriXX and 98.5%±1.88 (1SD) for ArcCHECK. A paired t-test was also performed for the groups of patients whose DQA was performed with both the ArcCHECK and MatriXX. No statistical dependence was found in terms of the Gamma pass rate for ArcCHECK and MatriXX. The considered 3D and 2D dosimeters have achieved similar results in performing routine patient-specific DQA for patients treated on a TomoTherapy unit.

1. Introduction

It is recommended standard practice that the Tomotherapy plan for each patient be checked in the form of delivery quality assurance (DQA) prior to treatment [1]. DQA is a procedure in which the patient plan is copied and delivered to a phantom. The deliverability and accuracy of the patient plan is verified by comparing the dose calculated by the treatment planning system (TPS) and measured by one detector or detector array inserted or embedded in the phantom.

A single ionization chamber with small air cavity can be used to verify the dose at single points in a phantom [2]. To measure a dose distribution across different locations in the phantom, an array of detectors is required. Detector arrays along with the phantom can be classified as a 2D or 3D dosimeter according to how the detectors are distributed geometrically in space [3, 4]. If an array of detectors are arranged at different points in 3D space but not limited to a plane, the dosimeter is usually called a 3D dosimeter or quasi-3D depending on the density of detectors in space. Gel


Content from this work may be used under the terms of the Creative Commons Attribution 3.0 licence. Any further distribution of this work must maintain attribution to the author(s) and the title of the work, journal citation and DOI.
Published under licence by IOP Publishing Ltd

dosimeter is a true 3D dosimeter [5, 6], but it has not been commonly used for clinical routine QA. Most dosimeters used routinely in most radiotherapy centres are either 2D or quasi-3D detectors. The advantage of a 3D or quasi-3D dosimeter over a 2D dosimeter is that it is able to measure a 3D dose distribution in a phantom. In nature, the dose delivered to the phantom or patient is delivered throughout a volume not constrained to a plane. Both 3D and 2D dosimeters, can only measure the doses at a certain number of locations within a phantom. In practice these locations are chosen to be in high dose regions with low gradient. The agreement between the calculated and measured dose is usually quantified using the Gamma index [7].

There are several commercial dosimeters suitable for Tomotherapy DQA. Among them are ArcCHECK™ [8] (Sun Nuclear, Melbourne, FL) and MatriXX Evolution™ [9] (IBA, Schwarzenbruck, Germany). These two dosimeters have been used in our clinic for performing patient-specific quality assurance for Tomotherapy treatment since 2012. ArcCHECK is a quasi-3D dosimeter, whereas Matrix Evolution is a 2D dosimeter. The purpose of this study was to review the DQA results over the previous three years and to investigate if there was a statistical difference between DQA results performed with a quasi-3D dosimeter and a 2D dosimeter.

2. Materials and Methods

2.1. ArcCHECK versus MatriXX Evolution

The ArcCHECK 3D dosimeter is a cylindrical acrylic phantom with an array of 1386 diodes that are positioned on the surface of cylinder measuring 21 cm in diameter [8]. The diode array forms a spiral path of 1 cm and 1 cm inter-detector distance and there are 66 diodes for each turn. This cylindrical-spiral detector pattern was designed to reduce the directional dependence. The phantom also has an outer diameter of 26.6 cm and an inner holes diameter of 15.1 cm, the active area length is 21 cm and active detector size of each diode is 0.8 x 0.8 mm^2. Another advantage of this dosimeter is that it has a 15 cm diameter cavity in the phantom that can hold an insert with an ionization chamber for point dose measurement. It can simultaneously measure the exit and entrance dose in 3D space.

As a 2D dosimeter, MatriXX Evolution is composed of the MatriXX and Multicube. The Matrix device is an array of 1020 vented pixel ion chambers [9]. The chambers are divided into 32 rows and 32 columns lying in a plane. The active area is 24 x 24 cm^2. The chambers have low angular dependence. MultiCube is a two-part plastic water phantom. The matrix device can be easily inserted into the MultiCube for measuring 2D dose distributions within the MultiCube.

2.2. DQA with ArcCheck and MatriXX Evolution

ArcCheck and MatriXX Evolution were commissioned and calibrated during the period of commissioning TomoTherapy Hi-ART unit in June, 2012. The dosimetric and mechanical performance of the Tomo therapy machine was ensured to be its optimal status by yearly, monthly, weekly and daily QA following the recommendation by AAPM protocol [1]. Since then, the DQA of patient plans have been performed by different clinical physicists but following the established Tomo patient DQA protocol.

A DQA plan for each patient was created using the DQA software tool installed on the planning work station. This procedure is similar to ones described in other literature [8, 9]. Briefly, a patient plan is opened using Tomo DQA software, ArcCHECK or MatriXX CT image data sets can be selected, then an IVDT (intensity-to-density value) curve was applied to the CT images for late dose calculation and the Tomo couch was inserted into the phantom CT images. The critical point for establishing a DQA plan is to move the phantom to make sure the detector plan of ArcCHECK or MatriXX in the high dose region. The high dose region is usually chosen to be within the planning target volume (PTV) of the patient. Once the detector plane is in the correct position, the red lasers were moved to coincide with the external marks on the ArcCHECK or MatriXX Evolution. The phantom was then setup on the Tomo couch, scanned using MVCT and registered to the planning kV CT images. The position of the phantom was adjusted and the DQA plan was delivered to the

phantom. Measured dose was then compared with TPS calculated ones. The Gamma map was calculated using 3mm distance tolerance and 3% of global maximum plan dose with threshold of 10%. This analysis was performed using the SNC software tool for ArcCHECK and OmniPro-I'mRT for MatriXX.

2.3. *Retrospective analysis of DQA results*

A total of 221 DQA plans were included in this study. These DQA plans corresponded to 215 patients treated in our clinic during the period from June 2012 to April, 2014. Tomotherapy was used to treat patients with a variety of diseases: Head-neck, breast wall and Pelvis. Over 90% of them were head-neck patients as Tomotherapy provided superior conformal dose to complicated targets while sparing the critical organs such as spinal cord, brain stem in head neck area, compared to other available options. For analysis, the DQA plans were divided into two subgroups: ArcCHECK subgroup and Matrix subgroup. A paired t-test for the gamma pass rate between the two subgroups was calculated.

3. Results and Discussion

Figure 1 and 2 showed the variation of Gamma pass rate for the patients measured with MatriXX and ArcCHECK, respectively. There were more patients measured with ArcCHECK than with Matrix due to efficiency considerations. If MatriXX was used for 2D dose measurements, another plan was created using the Tomotherapy cheese phantom for point dose measurement. The 2D dose map and point dose can be measured using one DQA plan for one patient by inserting the chamber and its holder into its cavity.

The Gamma pass rates were scattered in the same range between 92% and 100 % for both patients measured with MatriXX and ArcCHECK. The mean value and standard deviation were 98.2% ± 1.98 (1SD) for MatriXX and 98.5%±1.88 (1SD). There were several patients whose Gamma pass rates were below 95% for both MatriXX and ArcCHECK. Our local protocol for acceptable Gamma pass rate is no less than 95%. Further analysis indicated the detector planes for these patients were not in a high uniform dose region. Another DQA plan was created for these patients and all met local Gamma pass rate criteria.

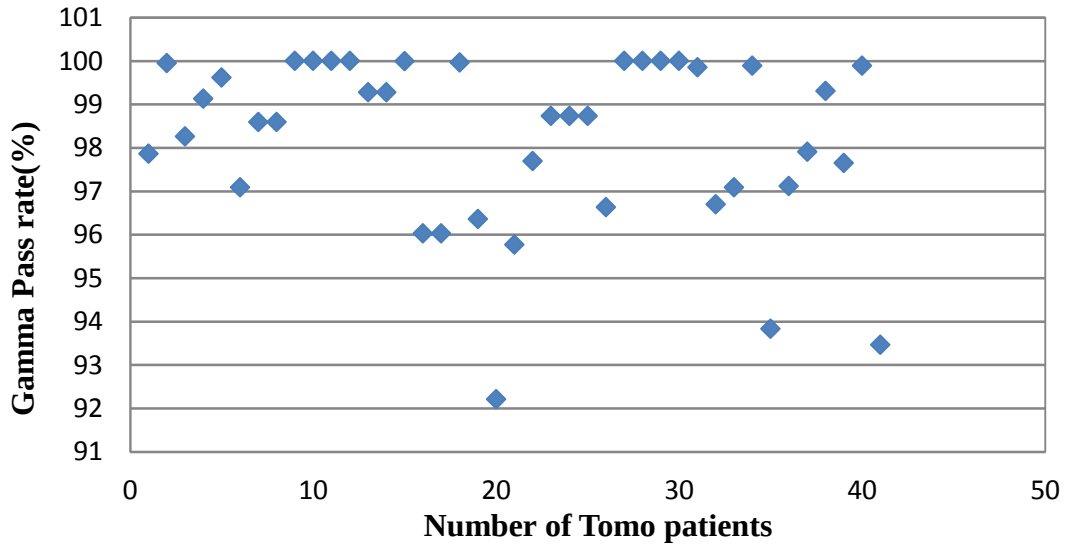

Figure 1. Gamma pass rates measured with MatriXX Evolution for each patient using 3mm/3% of global maximum planned dose with 10% dose threshold.

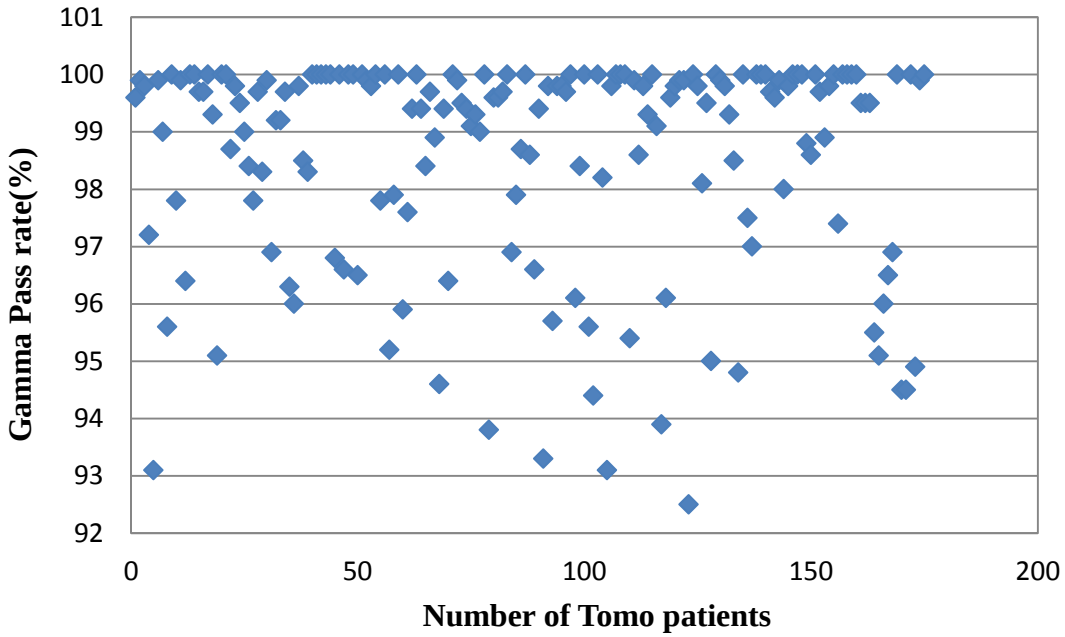

Figure 2. Gamma pass rates measured with ArcCHECK for each patient using 3mm/3% of global maximum planned dose with 10% dose threshold.

To evaluate the variability of the Gamma pass rate measured with ArcCHECK, we also analyzed the statistical dependence between these two patient DQA groups. A paired t-test was performed. In order to perform this test, the patient number in each DQA group has to be same. 41 patient DQA results were randomly selected from the whole ArcCHECK DQA results group. The t-test was run several times in this way. It was found the p-value for two-tail was greater than 0.09 and the p-value for one-tail is larger than 0.04. It was determined that there was no statistical difference for the Gamma pass rates measured with ArcCHECK and MatriXX.

4. Conclusion

Tomotherapy DQAs performed with a quasi-3D dosimeter or a 2D dosimeter for 215 patients in our centre were reviewed and analyzed. No statistical difference in Gamma pass rate values using these two types of dosimeters was found.

5. References

[1] Langen K M *et al* 2010 *Med. Phys.* **37** 4817-53
[2] Hill R *et al* 2009 *Med. Phys.* **36** 3971-81
[3] Greer P B *et al* 2007 *Med. Phys.* **34** 4389-98
[4] Vial P *et al* 2008 *Med. Phys.* **35** 1267-77
[5] Oldham M *et al* 2001 *Med. Phys.* **37** 1436-45
[6] Baldock C *et al* 2010 *Phys. Med. Biol.* **55** R1-63
[7] Low D A *et al* 2003 *Med. Phys.* **25** 656-61
[8] Neilson C *et al* 2013 *Med. Dosim.* **38** 77-80
[9] Xu S *et al* 2010 *Biomed. Imaging Interv. J.* **6** e24