monitor for quality assurance purposes. The ability of the IQM to detect additional error modes needs further investigation.

EP-1529

A real-time monitor system for QA and VMAT: sensitivity analysis in clinical practice

G. Guidi[1,2], N. Maffei[1,2], G.M. Mistretta[1], P. Ceroni[1], A. Ciarmatori[1,2], L. Morini[1], A. Bernabei[1], P. Giacobazzi[3], T. Costi[1]

[1]*Az.Ospedaliero-Universitaria di Modena, Medical Physics, Modena, Italy*

[2]*University of Bologna, Physics and Astronomy, Bologna, Italy*

[3]*Az.Ospedaliero-Universitaria di Modena, Radiation Oncology, Modena, Italy*

Purpose or Objective: The iQM® monitor system was tested to provide a method for treatment field verification using an independent monitor system mounted below the gantry. Real-time monitoring allows delivery errors to be detected during treatment, including record & verify mismatch, calibration errors or malfunctions in multi-leaf collimator (MLC), increasing patient safety.

Material and Methods: The iQM® system consists of a large area ion-chamber with a spatial gradient. The ionization chamber and the data acquisition software system were interfaced to an Elekta Synergy accelerator. During 6 months of VMAT quality assurance (QA) sessions, more than 70 sessions of measurements were carried out to validate the repeatability of the detector as a dedicated QA instrument. To evaluate efficiency in clinical practice, a dummy plan and a Head and Neck (H&N) VMAT plan were delivered and investigated using the system. The dummy plan was composed of 18 segments (17 segments 4x4 cm2 and 1 segment 10x10 cm2) and was delivered more than 100 times with constant 50 MU per segments. The VMAT plan was composed of 140 control points delivered by an arc, with low gantry speed, high MU and low dose rate. The sensitivity was then tested by introducing specific dosimetric increases of MU (1%,2%,3%,4%,5%,10% and 20%) in the H&N plan (VMATError Plan). Rotational analysis and validation were investigated; correlation with gantry and collimator angles was quantified using SPSS ANOVA analysis.

Results: The dummy plan delivered in standard condition (gantry and collimator angles=0°) revealed a mean variation in signal counts of 0.7±1.0% compared with the commissioning day. Independence of the detector with gantry position were investigated (gantry angle: 0°-90°-180°-270° and collimator angle: 0°-45°-135°-225°-315°). No statistical difference (significance ≈ 1) was detected for all segments, confirming the high quality of the instrument for daily QA. In the H&N plan, a decrease in measured counts was observed in the particular range of gantry angles from 120° through 240°. Statistical analysis showed a mean dose discrepancy of 2.8±1.0% between planned and measured errors from the original plan. For the VMATError Plan, the system is capable of detecting the error introduced with an agreement of 0.2±0.5% (R2=0.99). No correlation related to collimator angle and delivered MU was detected.

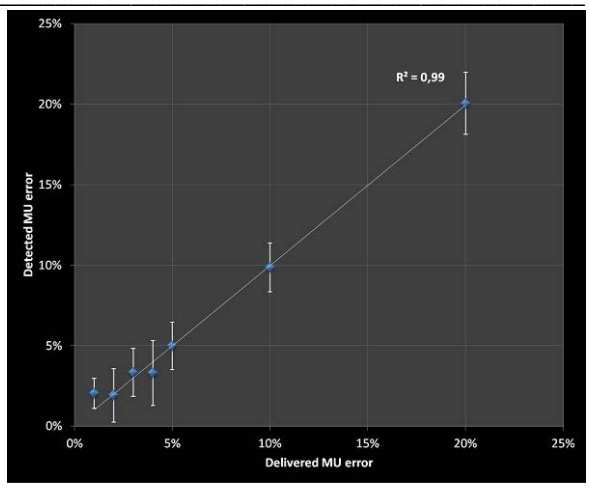

Figure 1 Correlation of MU detected vs. MU delivered with ad-hoc errors (1%,2%,3%,4%,5%,10%,20%)

Gantry angle (°)	MU error						
	1%	2%	3%	4%	5%	10%	20%
0	0,2%	1,0%	2,1%	1,8%	2,9%	7,9%	16,8%
20	2,5%	2,4%	3,1%	5,4%	4,1%	9,1%	21,1%
40	3,6%	4,6%	6,2%	5,6%	6,7%	12,3%	20,4%
60	1,4%	2,4%	3,1%	4,0%	5,4%	10,0%	20,3%
80	1,3%	0,8%	4,4%	2,7%	5,1%	9,1%	19,1%
100	2,4%	2,3%	3,5%	2,2%	4,5%	9,3%	19,6%
120	2,8%	1,2%	3,4%	3,6%	5,6%	9,3%	21,9%
140	1,6%	1,6%	4,8%	2,1%	4,4%	11,9%	18,9%
160	2,9%	2,8%	3,5%	3,3%	4,5%	8,4%	19,9%
180	1,8%	-1,8%	-0,3%	-0,4%	6,1%	9,2%	18,3%
200	1,8%	-0,4%	2,1%	0,9%	2,5%	9,3%	19,2%
220	0,9%	1,0%	1,4%	1,6%	2,5%	8,6%	18,7%
240	1,9%	1,7%	4,6%	3,3%	5,3%	8,9%	19,5%
260	2,8%	2,6%	3,8%	2,5%	5,6%	9,1%	20,1%
280	4,0%	5,2%	5,0%	8,0%	7,8%	12,9%	25,8%
300	2,1%	3,4%	3,1%	5,3%	4,5%	9,8%	20,5%
320	2,0%	3,4%	3,6%	4,5%	6,4%	12,0%	21,2%
340	2,0%	2,4%	4,6%	5,1%	6,8%	11,7%	22,4%

Table 1 Detected MU errors vs. Gantry angle

Conclusion: The system was shown to be stable for daily QA and could add many advantages to the patients' safety during treatment. Taking into account all the treatment factors, the detector provides punctual and cumulative output for each beam segment, which is compared in real time to each segment's expected value. The robustness of the measurement results suggests that the system could recognize errors or inadequate MU during the delivery. The significant signal deviation seen at particular gantry rotations could be investigated in order to improve the results obtained.

EP-1530

Machine performance check tool data analysis

P. Gago[1], J. Olasolo[1], C. Eito[1], M. Aylas[1], P. Ensunza[1]

[1]*Clinica IMQ Zorrotzaurre, Radiation Therapy, Bilbao, Spain*

Purpose or Objective: Machine Performance Check (MPC) is a tool provided with Varian TrueBeam linear accelerators to verify, prior to treatment, that critical functions of the system are within the established tolerances. An evaluation carried out by Clivio et al. compared the results of the checks they made using the MPC application and their independent measurements. The purpose of this analysis is to compare the result obtained with the MPC tool at our institution with those acquired in the mentioned study.

Material and Methods: In order to perform the MPC checks, the IsoCal phantom has to be mounted to the couch top using an appropriate holder. The system acquires a series of MV and kV images and analyses them in order to obtain values for different parameters. Two distinct types of checks can be carried out with MPC: beam constancy checks and geometry checks. With the first ones beam output, uniformity and center shift can be evaluated. Geometry checks give us information about isocenter's size, imaging devices positioning, gantry, MLC, collimator, jaws and couch positioning. We analyzed the data obtained over 15 weeks of measurements in a TrueBeamSTx 2.0 with a Millenium HD120MLC and a DMI imager. Beam checks were done for all

the available photon energies in our TrueBeam: 6MV, 15MV, 6MV FFF and 10MV FFF. Geometrical checks were measured only for the 6MV beam.

Results: In all our measurements we found that the results were within the established tolerances. The value of the isocenter's size is, in our case, 0.27 mm, very close to that obtained by Clivio et al. for the same energy, 0.34 mm. The values of the 6MV beam center shift, MV imager projection offset and absolute gantry positioning are the same that the ones obtained in the mentioned study: 0.04 mm, 0.17 mm and -0.09° respectively. For that same energy the offset of the collimator rotation is, in our case, 0.15°, while the one reported in the study is 0.17°, and the kV imager projection offset, 0.24 mm versus 0.32 mm. The output change in our TrueBeam varies from -0.58% for the 10MV FFF beam to -0.50% for the 6MV beam. In the study these values range from 0.06% for their 15 MV beam to 0.24% for their 6MV FFF beam.

Conclusion: Our TrueBeam MPC results were compared with those obtained by Clivio et al. at their institution. They show great agreement with those reported in their study. We have established MPC tool measurements as part of our routine daily QA.

EP-1531

Comprehensive commissioning and QA of the new version upgrade of treatment planning system

J. Peng[1], D. McDonald[1], N. Koch[1], M. Ashenafi[1], C. Mart[1], J. Dise[1], M. Fugal[1], K. Vanek[1]

[1]*Medical University of South Carolina, Radiation Oncology, Charleston, USA*

Purpose or Objective: To evaluate the dosimetric and optimization algorithm accuracy of a newly released version 13.5 of the Eclipse treatment planning system (TPS) prior to upgrade, utilizing the recently published AAPM Medical Physics Practice Guideline (MPPG), "Commissioning and QA of treatment planning dose calculations".

Material and Method: Eclipse V13.5 includes many novel features, such as contouring tool enhancements, streamlined 4D CT contouring, new physical materials for the AcurosXB (AXB) dose algorithm, and faster optimization engines. MPPG phantom tests were performed to validate both static and dynamic beams in both homo- and hetero- generous material. Additionally, 54 patient plans were re-calculated in V13.5 with the same beam parameters, monitor units, and dose algorithms in order to examine algorithm difference. A dose-difference plan was created by subtracting the dose calculated in V13.5 from V11 and evaluated in 3D dose display. Those re-calculated patient plans included a variety of treatment sites, energies, and techniques. However, the new Photon Optimizer (PO) algorithm was developed in V13.5 to replace the previous Dose Volume Optimizer (DVO) in IMRT and Progressive Resolution Optimizer (PRO) in VMAT. In order to compare the PO and DVO/PRO optimizers, 25 IMRT/VMAT clinical plans were re-optimized with PO using the same objectives, prescriptions, and number of iterations. The plan quality and optimization time were examined.

Results: Dose differences for all clinical cases and MPPG phantom tests in-field and in homogeneous areas, were within 1% and 3% for photon and electron plans, respectively. Although the beam models were not re-commissioned in V13.5, the dosimetric leaf gap (DLG) value was modified and the new physical material was added in AXB; as a result the dose differences correspond to differences in the dose algorithms. Therefore, at field edges and heterogeneity interfaces, maximum dose differences increased to 3% and 6% for photons and electrons, respectively. Dose calculated using AXB was found to be 3% less at the lung interface and inside the lung in V13.5 compared to dose calculated in V11, but no dose difference calculated using AAA was seen. PO could optimize plans 20-30% faster than DVO/PRO. For most cases, no significant difference in plan quality was noted. However, lung SBRT cases with PO showed a reduction in MUs and slightly improved dose conformity.

Table I : The mean and maxium dose difference of the same dose algorithms between V11 and V13.5 in 3D (photon and electon), VMAT , SBRT and SRS cases.

Machine #1 _Varian True Beam with HD MLCs

3D Photon

Treatement Site	Field #	Energy (MV) + Accessory	Mean Dose Diff. (V11-V13.5)	Max. Dose Diff. (V11-V13.5)
MPPG Phantom (all energy and fields)			0.7%	-2.3%
Lt Breast	4	6X+10X	<0.5%	0.9%
Larynx	2	10X+EDW	0.8%	-1.5%
Lung	2	10X	<0.5%	0.8%

3D Electron

Treatement Site	SSD(cm)	Energy (MeV)	Mean Dose Diff. (V11-V13.5)	Max. Dose Diff. (V11-V13.5)
MPPG Phantom (all energy and fields)			0.8%	5.2%
TBI Rib Boost	105	6e	1.1%	3.1%
Scalp	105	9e	1.5%	3.1%
TBI Rib Boost	105	12e	1.4%	1.8%
TBI Rib Boost	105	16e	1.8%	2.0%

VMAT

Treatement Site	Arcs #	Energy (MV) + Accessory	Mean Dose Diff. (V11-V13.5)	Max. Dose Diff. (V11-V13.5)
Lung	2	10x	0.5%	1.7%
Mediastinum	2	10x	<0.5%	0.9%
HN	2	6X	<0.5%	1.1%
Brain	4	6X	<0.5%	1.2%

Treatement Site	Arcs #	Energy (MeV)	Mean Dose Diff. (V11-V13.5)	Max. Dose Diff. (V11-V13.5)
Brain	4	6X	0.6%	1.5%
Lung	2	10X	<0.5%	1.7%
Lung	2	10X	0.6%	1.9%

SBRT

Treatement Site	Fields#/ Arcs #	Energy (MV) + Accessory	Mean Dose Diff. (V11-V13.5)	Max. Dose Diff. (V11-V13.5)
liver SBRT	9	10x	-0.6%	-1.2%
Adrenal SBRT	9	10x	-1.0%	-2.9%
Lung SBRT	9	6X+10X	-1.2%	-1.9%
Lung SBRT	5	6X	-0.8%	-1.4%
Lung SBRT	3	6X	-0.9%	-1.5%
Adrenal SBRT	3	10X	-0.4%	-1.1%
Lung SBRT	4	6X	-0.7%	-1.3%

SRS

Treatement Site	Arcs #	Energy (MeV)	Mean Dose Diff. (V11-V13.5)	Max. Dose Diff. (V11-V13.5)
Spine SRS	3	6X	<0.5%	-1.1%
Spine SRS	6	6X	<0.5%	-1.2%
Spine SRS	6	6X	<0.5%	-1.1%
Brain SRS	3	6X	<0.5%	-1.6%

Machine #2 _Varian iX

3D Photon

Treatement Site	Field #	Energy (MV) + Accessory	Mean Dose Diff. (V11-V13.5)	Max. Dose Diff. (V11-V13.5)
MPPG Phantom (all energy and fields)			0.50%	-2.1%
Rt Breast	2	6X	<0.5%	0.7%
Pelvis	3	16X + EDW	<0.5%	0.7%
Lung	5	6X	0.6%	-2.8%
Lung	3	16X	<0.5%	0.9%
Brain	2	6X+16X	0.7%	-1.2%
Pelvis	4	16X	<0.5%	-2.5%
whole brain	2	6X	0.6%	-1.6%
Hip	2	16X	0.8%	-1.8%

3D Electron

Treatement Site	SSD(cm)	Energy (MeV)	Mean Dose Diff. (V11-V13.5)	Max. Dose Diff. (V11-V13.5)
MPPG Phantom (all energy and fields)			0.7%	5.8%
Breast Boost	105	6e	1.0%	4.1%
Breast Boost	100	9e	1.9%	4.9%
Breast Boost	100	12e	1.4%	3.7%
Sternum	100	16e	1.3%	5.0%
Breast Boost	100	20e	1.1%	6.1%

VMAT

Treatement Site	Arcs #	Energy (MV) + Accessory	Mean Dose Diff. (V11-V13.5)	Max. Dose Diff. (V11-V13.5)
IR Prostate	2	16X	<0.5%	1.0%
Pelvis	2	6x	<0.5%	1.1%

Treatement Site	Arcs #	Energy (MeV)	Mean Dose Diff. (V11-V13.5)	Max. Dose Diff. (V11-V13.5)
breast+IM+SC	6	6x	<0.5%	1.4%

Machine #3_TrueBeam with regular MLCs

3D Photon

Treatement Site	Arcs #	Energy (MV) + Accessory	Mean Dose Diff. (V11-V13.5)	Max. Dose Diff. (V11-V13.5)
MPPG Phantom (all energy and fields)			0.50%	-2.5%
Pelvis	4	16X	0.7%	-1.8%
Rt. Breast	4	6X	<0.5%	0.7%
Brain	2	6X+16X	0.7%	-1.9%
Lt Lung	3	6X+16X	0.5%	-1.7%

3D Electron

Treatement Site	Arcs #	Energy (MeV)	Mean Dose Diff. (V11-V13.5)	Max. Dose Diff. (V11-V13.5)
MPPG Phantom (all energy and fields)			1.0%	6.1%
Breast Boost	105	6e	1.2%	3.5%
Breast Boost	100	9e	1.1%	4.1%
Breast Boost	105	12e	1.5%	6.3%
Rt Axilla	105	16e	1.8%	3.2%

VMAT

Treatement Site	Arcs #	Energy (MV) + Accessory	Mean Dose Diff. (V11-V13.5)	Max. Dose Diff. (V11-V13.5)
Prostate	2	6x	<0.5%	1.1%
HN	2	6x	<0.5%	1.0%
Lung	2	6x	<0.5%	1.4%

Treatement Site	Arcs #	Energy (MeV)	Mean Dose Diff. (V11-V13.5)	Max. Dose Diff. (V11-V13.5)
Prostate	2	16x	<0.5%	1.5%
breast+IM+SC	6	6x	<0.5%	1.8%
HN	2	6x	<0.5%	1.3%

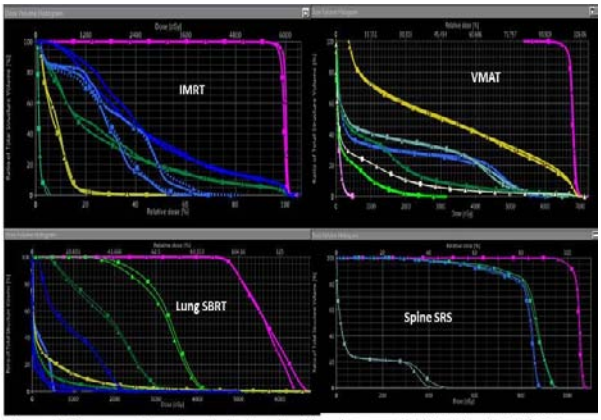

Figure 1. The comparison of optimization algorithms between PO (V13.5) and DVO/PRO (V11) in IMRT, VMAT, Lung SBRT and Spine SRS cases. The square dots present DVO/PRO algorithms in V11 and triangle dots show PO algorithms in V13.5

Conclusion: Commissioning and QA of new TPS version is essential prior to clinical release. The tests suggested by MPPG provide an excellent framework for this work, particularly when combined with additional clinical cases. Dose differences noted were chiefly located at beam edges, possibly due to modified DLG values, and in heterogeneous materials and interfaces using AXB, potentially due to differences in material specification. The PO improved optimization efficiency in all cases and MU economy and dose conformity in some SBRTs, with no reduction in plan quality.

EP-1532

Reliability of the Machine Performance Check application for TrueBeam STx Linac

V. Mhatre[1], P. Patwe[1], P. Dandekar[1]

[1]*Sir HN RF Hospital, Radiation Oncology, Mumbai, India*