Valutazione e confronto di diversi sistemi commerciali per controlli di qualità per IMRT e VMAT

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INTRODUCTION AND PURPOSE

Patient-specific plan QA for Intensity Modulated Radiotherapy and Volumetric radiotherapy techniques has the purpose to identify possible delivery errors before the treatment. Many commercial systems are currently available for this purpose.

The aim of the study is as follows:

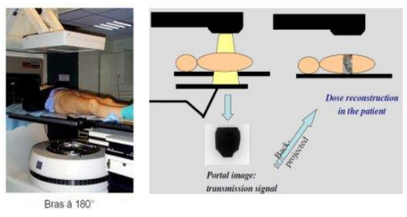
- To describe the use of, and results from, various dosimetric systems employed for patient-specific plan QA
- To report their sensitivity in detecting possible delivery errors
- To report their accuracy in the calculation of the dose

MATERIALS AND METHODS

The systems analysed in this work were: Compass (IBA), Epigray (Dosisoft), and ARCcheck+3DVH (SunNuclear).

1. Compass - IBA

2. Epigray - Dosisoft



3. ARCcheck & 3DVH - SunNuclear

Fig. I : commercial systems analysed in this work: (1) Compass; (2) Epigray; (3) ARCcheck+3DVH.

See references [1,2,3] for a detailed description of the systems.

The analysis was performed comparing the dose distributions obtained in a simple geometry (homogeneous slab phantom) and also in the CT scan of patients.

The Treatment Planning System (TPS) used to obtain the optimization of IMRT and VMAT plans was Pinnacle ver. 9.2 with the module SMARTarc. The linear accelerator used is the SynergyS® ELEKTA with beam modulator, with 0.4 cm width leaf and 40 leaves. The largest field is 21x16 cm^2.

In the homogeneous phantom, a point by point comparison was made between the dose reconstructed by the systems and calculated with the TPS versus the dose measured with an ion chamber in a corresponding geometry.

For the patient plans comparison, different type of tretaments were selected: 5 prostate lesions, 3 brain lesions and 1 Head&Neck lesion.

Both IMRTand VMAT plans were considered in the analysis.

From the TPS the DICOM RTPlan, RTDose, RTStructures and the CT images were exported into the three systems.

After the delivery of the beams, the dose is reconstructed in different ways by the systems: a) **Compass** predicts the dose according to the RT plan with a correction derived from 2D measurements of a matrix detector. b) **Epigray** does a back projection of the transit signal acquired during the treatment session and reconstructs the dose into the patient with a simplified dose algorithm. c) the **3DVH** software uses the differences between the measured dose distribution (with any device like Mapcheck, Arccheck, or EPID) and the planned dose, to "perturb" the dose calculated by the TPS, in order to reconstruct the actual delivered dose. This reconstructed dose is used to calculate local and global gamma and the DVHs within the outlined structures in the plan.

RESULTS

COMPASS: The comparison between the predicted dose (from the TPS) and the reconstructed dose with the Compass system in the simple geometry of the slab phantom with beams 5.6x5.6 cm^2, 10x10 cm^2 and 15.2x15.2 cm^2, shows differences within 1% to max 3% in single points (5, 10, 15 and 20 cm depths). The comparison between patient plans and reconstructed dose from measurements shows that for IMRT plans (5 beams delivered with Step and Shoot technique) the agreement between the two systems is better than for VMAT plans. In general, the dose distributions reconstructed by Compass have a lower total dose at the plan of the isocenter and exhibit discrepancies in the penumbra of the beamlets . This is also demonstrated in the gamma analysis (in the lower right corner of the figures).

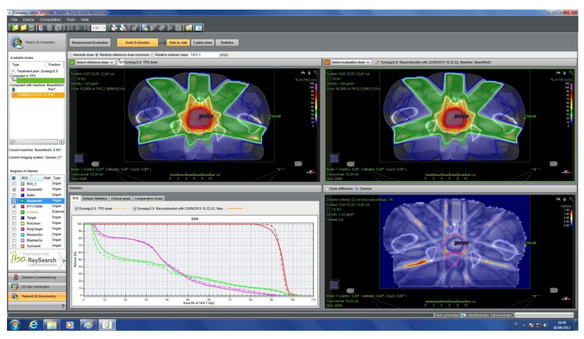


Fig. 2: Pinnacle (up left) and reconstructed dose by Compass (up right)dose distributions. Example of an IMRT prostate plan.

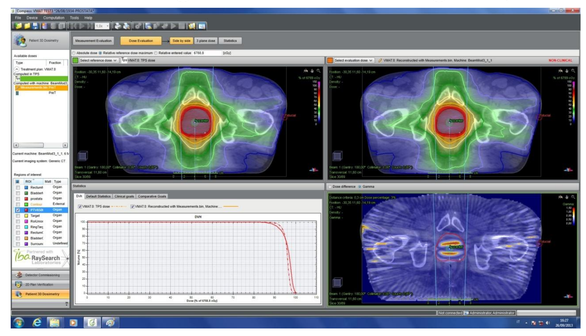


Fig. 3: Pinnacle (up left) and reconstructed dose by Compass (up right)dose distributions. Example of a VMAT prostate plan.

Epigray: the comparison between the dose calculated by Pinnacle and the dose reconstructed by the Epigray system in the slab phantom is within 2%. The discrepancy increases when the beams are parallel to slabs (gantry=90°). In this case the difference is up to 4%. In the patients, since Epigray reconstructs the dose in the CT of the patient from portal images (IVIEWGT™-ELEKTA) by using a simplified algorithm [2] compared to a real TPS, discrepancies on single points can be in the range of 7% to10% depending on the position arbitrarily chosen for the point. A gamma analysis for each beam is available and also a 3D dose reconstruction which gives a comparison between the DVHs of the contoured structures.

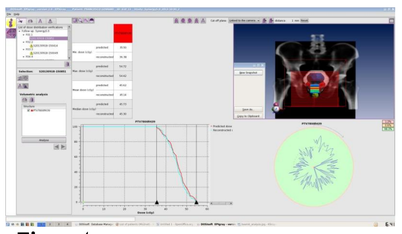
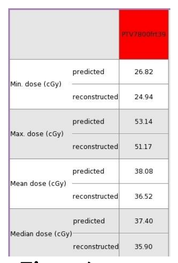


Fig. 4

Point name	Prescription	PT_F3_F4	PT_F1
Date	18 Sep 2013	18 Sep 2013	18 Sep 2013
Time	15:00	15:00	15:00
Imaging station	Italie0	Italie0	Italie0
TT unit	SynergyS	SynergyS	SynergyS
Méthode de reconstruction dosimétrique	FiniteTMRs method V2.0.3	FiniteTMRs method V2.0.3	FiniteTMRs method V2.0.3
Point Depth (mm)	180.53	184.51	176.79
Point radiological depth (mm)	184.5	192.37	173.99
Source-image distance (mm)	1600	1600	1600
Equivalent square field size (mm)	57.67	57.67	57.67
Formalism factor	0.205e(1e-3)	0.19e(1e-3)	0.209e(1e-3)
Valeur image EPI utilisée (u.l.)	180598	180795	186688
Reconstructed dose (cGy)	37.03	34.28	39.03
Predicted dose (cGy)	41.46	34.78	40.2
Relative deviation % (reconst. / predicted)	-10.69	-1.44	-2.9
Gamma index local	0.54	0.29	0.3
Gamma index global	0.54	0.24	0.3

Fig. 5



		PTVBOOST4125
Min. dose (cGy)	predicted	26.82
	reconstructed	24.94
Max. dose (cGy)	predicted	53.14
	reconstructed	51.17
Mean dose (cGy)	predicted	38.08
	reconstructed	36.52
Median dose (cGy)	predicted	37.40
	reconstructed	35.90

Fig. 6

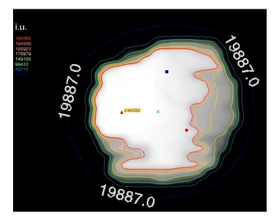


Fig. 7

Fig. 4-7: from left to right: DVHs for the PTV calculated by the TPS (red) and reconstructed; Epigray gives a lower dose on average compared to Pinnacle. Table with the points and gamma analysis for the selected beam; for one point the discrepancy is -10%, because it is positioned in a high dose gradient area, but the gamma is lower than 1. Table with the predicted (TPS) and reconstructed doses (min, max, mean and median) for the selected beam; the mean dose calculated over 3 points is -4% compared to Pinnacle. Representation of the isodoses on the portal image for the selected beam.

3DVH: this system has provided a quite high passing rate (92%) for gamma criterion 1 Gy absolute dose and 2 mm DTA for this complex VMAT plan (a prostate with pelvic lymphnodes plan). The variation (fig. 8) for the mean dose within the PTV is about -0.8% while for the max dose is about 3%. The gamma analysis gives a passing rate of 86% for the voxels within the PTV (fig. 9).

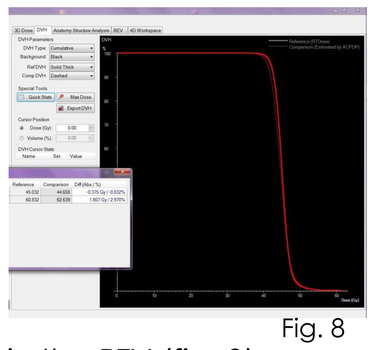


Fig. 8

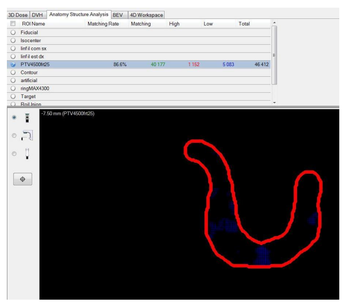


Fig. 9

DISCUSSION AND CONCLUSIONS

In principle, the three commercial systems analyzed in this work could be useful tools for quality assurance of treatment plans delivery.

However, it appears that their accuracy in dose determination has some limitations related to the low resolution of the ion chambers array and beam modeling for the Compass system; to the simple algorithm used for dose reconstruction from EPID images for the Epigray system; to the several corrections applied to the planned dose from the measurements to obtain the so called "revised patient dose"[4] in the 3DVH system. Some of the systems are still under active development to mitigate their limitations and we are planning to continue their evaluation.

BIBLIOGRAPHY

[1] "Experimental validation of a commercial 3D dose verification system for intensity-modulated arc therapies" R. Boggula, F. Lorenz,2, L. Mueller, M. Birkner, H. Wertz, F. Stieler, V. Steil, F. Lohr and F. Wenzra. Phys. Med. Biol. 55 (2010) 5619–5633.

[2] "In vivo dose verification from back projection of a transit dose measurement on the central axis of photon beams." P. Francois, P. Boissard, L. Berger, A. Mazal. Physica Medica (2011) 27, 1-10.

[3] "3D DVH-based metric analysis versus per-beam planar analysis in IMRT pretreatment verification." P. Carrasco, N. Jornet, A. Latorre, T. Eudaldo, A. Ruiz, and M. Ribas. Med. Phys. 39 (8), (2012) 5040-5049.

[4] "3DVH: on the accuracy of the Planned Dose perturbation algorithm". White paper, Sun Nuclear Co.