Implementation of a gantry mounted ion chamber for the machine QA and clinical routine

R. Nachtigall*, S. Peters, S. Frömbgen, N. Alizadeh Azbari, O. Bislich, PD Dr. med. F. Fehlauer
Strahlenzentrum Hamburg MVZ / CyberKnife-Center Hamburg

Strahlenzentrum Hamburg MVZ

cyberknife center hamburg

Introduction

Usually the quality assurance (QA) and patient plan verification take place after the patient treatments. With increasing patient numbers, and effort of the machine QA due to improved and new radiation techniques, the expenditure of time increases, too. The IQM-system offers a possibility to save and optimize time. In which extent, while keeping quality standards, will be investigated at the example of the patient plan verification.

Materials & Methods

Since October 2023 the IQM runs in parallel to the SunNuclear ArcCheck phantom (AC), which is the established patient QA at our institution. The analysis is set to various treatment techniques and indications. In particular 10 patient plans are cross checked on all linacs in our institution (L3, L4, L5) and analysed by global gamma index (AC) vs. consistency deviation (IQM). Furthermore, different errors are provoked to test the rigidity of the IQM system. Therefore, a static field of 10x10 cm² with 100 MU is used, which is also cross checked with the AC phantom. According to the watch (±3%) and action (+5%/-7%) levels of the IQM systems protocol our internal verification protocol (>95% agreement at Gamma 3%/3mm) is adopted. Every analysis below our 95% standard is defined as action level. To differentiate further at Gamma 2%/2mm the watch level is between 90%-95% and the action level below 90%.

Results

The qualitative and quantitative comparison to the AC shows a reasonable reliability of the IQM. The IQM is also sensitive to field changes and manipulations, resulting in error messages and non deliverable fields when there is a MU mismatch, and in watch and action level notifications when the field size varies (see Tab 1).

field size [cm]				Dose [MU]	AC [%]			IQM [%]	comment
x1	x2	y1	Y2		γ 3%/3mm	γ 2%/2mm	γ 1%/1mm		
5	5	5	5	100	100	98,3	77,9	-1,94	
5	5	5	5	105	89,2*			Error	*hot total field
5	5	5	5	101	100	97,9	74,2	Error	
4,5	5	5	5	100	91,6*			7,16**	*cold edge, **action level
4,7	5	5	5	100	100	92,9*	71,8	-4,96**	*cold edge, **watch level
5	5	5,2	5	100	100	98,4	72,7	0,69	

Tab 1: Standard field of 10x10 cm² and 100 MU with the manipulations and the resulting watch and action level.

		AC				IQM		
Technique	**Dataset**	Gamma	L3 [%]	L4 [%] (L3-Dose-Cal)	L5 [%] (L3-Dose-Cal)	L3 [%]	L4 [%]	L5 [%]
IMRT	sum	2,5% / 2,5mm	99,0	95,7	99,3			
	field 1		100,0	93,8	99,6	-1,6	-0,1	-0,3
	field 2		100,0	92,9	100,0	-3,0	-1,4	0,6
	field 3		100,0	100,0	100,0	-0,6	0,4	2,9
	field4		99,7	99,0	99,6	-2,9	-1,3	-1,2
	sum	2,5% / 2,5mm	99,6	97,3	98,7			
	field 1		99,7	97,6	98,1	-3,5	-2,4	-1,8
	field 2		100,0	98,7	99,5	-1,4	0,1	0,4
	sum	2,5% / 2,5mm	100,0	99,4	99,8			
	field 1		100,0	100,0	99,4	-1,9	0,1	0,7
	field 2		100,0	95,0	96,7	-1,7	0,1	0,8
	field 3		100,0	98,8	100,0	-2,5	1,0	0,0
VMAT	sum	2,5% / 2,5mm	98,6	97,6	99,7			
	field 1		98,4	99,5	99,5	-2,6	-0,1	0,4
	field 2		99,2	99,3	97,5	-0,4	1,7	1,9
	field 3		99,6	97,7	98,7	-2,7	0,6	1,8
	field 4		96,9	96,6	97,9	-3,9	-1,4	-0,7
	sum	2,5% / 2,5mm	92,5	94,8	96,1			
	field 1		97,4	98,5	98,8	-3,1	-1,1	-1,2
	field 2		96,5	97,1	96,4	-2,6	-0,8	-0,8
	sum	2,5% / 2,5mm	99,8	99,6	99,8			
	field 1		99,8	99,6	100,0	-1,7	-0,8	-0,1
	field 2		99,5	98,9	99,5	-1,6	-0,2	0,4
	field1	2% / 2mm	99,2	98,4	99,1	-2,2	-0,9	-0,3
	sum	2,5% / 2,5mm	99,8	99,8	99,8			
	field 1		99,6	99,3	99,6	-2,8	-1,5	-0,5
	field 2		98,1	98,5	99,1	-3,4	-1,1	-0,9
VMAT fff	sum	2% / 2mm	99,3	99,8	99,3			
	field 1		98,3	98,3	98,1	0,4	0,5	1,6
	field 2		98,0	99,0	98,8	-0,2	0,1	1,5
	Sum	3% / 3mm	99,6	98,2	99,4			
	field 1		98,5	97,6	97,1	-2,4	-1,9	0,0
	field 2		97,8	98,6	98,7	-1,3	-1,2	0,8
	field 3		99,0	96,8	98,5	-1,9	-2,5	0,1

Tab 2: Patient plan QA comparison of various indications.

The patient plan QA indicated no serious difference between the systems, and rarely exceeds to the watch level of both (see Tab 2). Also a segment-wise analysis of IMRT plans (e.g. deleting single segments) leads in both cases to errors, while the AC requires attention during the beam split, the IQM prevents the beam application a priori.

Summary

The IQM offers a reliable alternative to the phantom based patient plan verification offering the possibility to shift the QA to the first treatment fraction. This parallelises process in patient QA and treatment, and opens time slots. Furthermore, is proves to be rigid to the patient plans, preventing beam application when mismatches of filed MUs, and patient IDs occur. Apart from the performance of the IQM a cross check with an array based phantom is recommended on a regular base. A detailed investigation of the possibilities for the machine QA is still ongoing, while in parts already implemented for the dose rate QA.

*contact: rnachtigall@szhh.de