JULY 12–16 2020 VIRTUAL JOINT AAPM | COMP MEETING
EASTERN TIME [GMT-4]

Development of QA programs for the Halcyon linac

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INTRODUCTION

The newly released Ring Design System (RDS), Halcyon (Varian Medical Systems, Palo Alto, CA), has a different gantry head design from C-arm type linacs and does not equip with light fields or a flattening filter.

Set-up for the Halcyon linac

- Patients are positioned outside the gantry at the virtual isocenter pointed by lasers(Fig. 1), then the couch moves to the Isocenter by known 3D 0ffset (long, lat, and, vert).
- Since the patient's position cannot be confirmed using the light fields, image guidance is essential in each treatment.

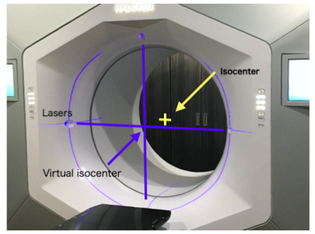

Fig. 1. Virtual isocenter of the Halcyon linac

Fixed MLC sequences for flattened beams

In conventional treatment, 6 patterns of fixed MLC sequences are used in which the upper MLCs move in a certain direction to flatten beams and give uniform dose in irradiation fields.

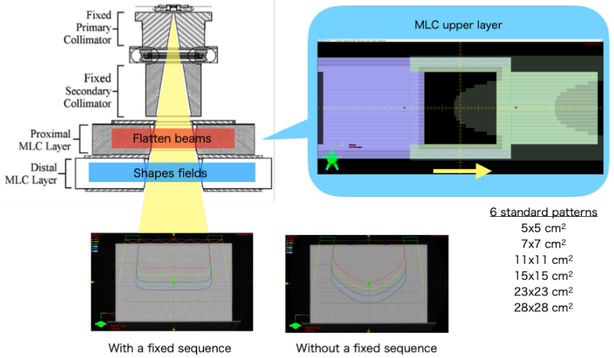

Fig.2. Schematic drawing of the Halcyon head assembly and fixed MLC sequences (Adapted from Ref. [1])

RESULTS

Table 1. Developed QA programs and tools for the Halcyon linac

Procedures	Daily	Monthly	Annual
Dosimetry			
PDD constancy	---	---	BEAMSCAN[a], Semiflex3D chamber[a]
OAF constancy	---	EPID[b]	BEAMSCAN[a], Semiflex3D chamber[a]
Flatness change from baseline	---	---	BEAMSCAN[a], Semiflex3D chamber[a]
Symmetry change from baseline	Quick Check[a]	---	BEAMSCAN[a], Semiflex3D chamber[a]
Output factor constancy	Quick Check[a]	---	BEAMSCAN[a], Semiflex3D chamber[a]
X-ray output constancy	Quick Check[a]	MP-3 XS[a], Farmer chamber[a]	BEAMSCAN[a], Semiflex3D chamber[a]
Beam quality (TPR20, 10)	Quick Check[a]	---	BEAMSCAN[a], Semiflex3D chamber[a]
X-ray output constancy vs gantry angle	---	---	Farmer chamber[a]
OAF constancy vs gantry angle	---	---	EPID[b]
Monitor unit linearity	---	---	BEAMSCAN[a], Farmer chamber[a]
MLC transmission	---	---	BEAMSCAN[a], Farmer chamber[a]
Leaf position accuracy (Picket fence)	MPC[b]	EPID[b]	EPID[b]
OAF constancy for flattened beams	---	EPID[b]	Mapcheck[c]
OAF constancy vs gantry angle for flattened beams	---	---	EPID[b]
Mechanical			
Collimator rotation isocenter (Spoke shot)	MPC[b]	EPID[b]	RT-QA2[d]
Gantry rotation isocenter (Spoke shot)	MPC[b]	RT-QA2[d]	RT-QA2[d]
Collimator angle indicators	MPC[b]	EPID[b]	RT-QA2[d]
Gantry angle indicators	MPC[b]	RT-QA2[d]	RT-QA2[d]
Indicator and radiation field coincidence	MPC[b]	EPID[b]	RT-QA2[d]
Couch travel	MPC[b]	Graph paper	---
Table top sag	---	---	Weights, Angle indicator
Radiation and mechanical isocenter coincidence	MPC[b]	---	IsoCube phantom[e], EPID[b]
Imager projection offset (MV/kV)	MPC[b]	---	---
Virtual-to-isocenter distance	MPC[b]	IsoCube phantom[e], EPID[b]	---
IGRT			
Imaging and treatment coordinate coincidence	MPC[b]	IsoCube phantom[e], EPID[b]	IsoCube phantom[e], EPID[b]
Positioning/repositioning	IsoCube phantom[e], EPID[b]	IsoCube phantom[e], EPID[b]	---
Image quality (2D-kV)	---	---	LasVegas phantom[b], Leads phantom[b]
Image quality (kV-CBCT)	---	---	Catphan phantom[f]
Imaging dose	---	---	CTDI chamber[g], CTDI phantom

The QA programs were developed according to AAPM Task Group 142[2](Table1). The vendor's system test, Machine Performance Check (MPC), is utilized for the mechanical and IGRT tests in the daily QA. Electronic portal imaging devise (EPID) mounted on the Halcyon linac is used as a 2D-array for efficient data acquisition in clinical routine.

[a] PTW, Freiburg, Germany
[b] Varian Medical Systems, Palo Alto, CA
[c] Sun Nuclear, Melbourne, Australia
[d] IPS, Wayne, New Jersey
[e] CIRS, Asbury Ave Norfolk, VA
[f] The Phantom laboratory, Salem, NY
[g] Radcal, Monrovia, CA

Basic machine performance of the Halcyon linac

X-ray output was adjusted twice since the start of clinical use and maintained within ±1% over a year (Fig.3.). In the monthly QA, the isocenter size for collimator and gantry rotation was about 0.2±0.1 mm and 0.3±0.1 mm on average, respectively. In annual QA, deviation from the baseline of TPR20,10 and PDD was 0.3% and within 0.4 % after d_{max} (Fig. 4.). No significant change was found in beam quality.

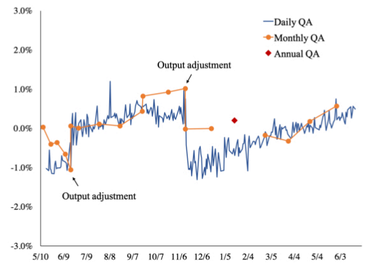

Fig.3. X-ray output constancy

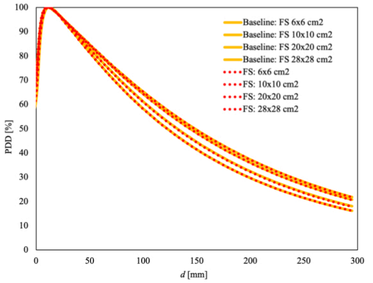

Fig.4. PDD constancy

QA for fixed MLC sequences

OAFs inside 80% field width were evaluated. Deviation of the OAFs from the baseline was 0.4±0.2% and 0.5±0.3% in the cross- and in-line direction through the center, respectively. Gantry angle dependency was observed at gantry 180 degree. Deviation of the OAFs from gantry 0 degree was 1.9% and 1.1% in the cross- and in-line directions. (Fig. 5).

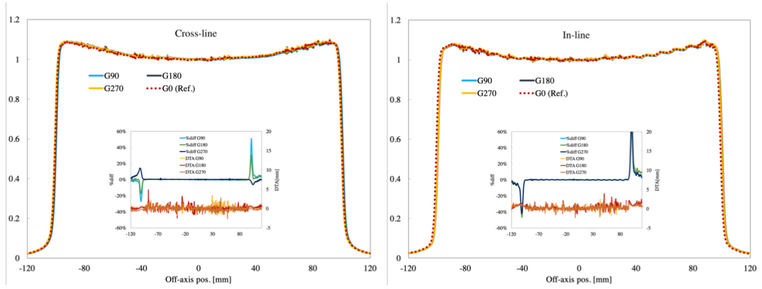

Fig.5. OAF constancy vs gantry angle for flattened beams

AIM

The purpose of this study was to develop and implement quality assurance (QA) programs for the Halcyon linac and to evaluate the machine stability over one year.

CONCLUSIONS

The developed QA programs were useful for the Halcyon linac. Good machine stability was obtained over a year.

REFERENCES

[1] **Lim T-Z et al**. Characterization of the Halcyon™ multileaf collimator system. *J Appl Clin Med Phys 2019; 20:4: 106–114*
[2] **Klein E-E et al.** Task Group 142 report: Quality assurance of medical accelerators. *Med. Phys., 2009; 36:9: 4197-4211*

CONTACT INFORMATION

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