Updating IROC Houston QA Center's reference photon dosimetry dataset for Elekta linear accelerators

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ABSTRACT

Purpose: To identify and consolidate contemporary dosimetric performance data for Elekta linear accelerators (linac) including specialized beams such as flattening-filter free (FFF) beams, which were not included in the original IROC reference dosimetry dataset.

Methods: Dosimetric data for Elekta linacs were aggregated from IROC's site visits conducted from 2012 to 2026. Point measurements were acquired in a water phantom at a source-to-surface distance of 100 cm and included percent depth dose, output factors, off-axis factors, and wedge factors for 6, 10, 15, and 18 MV flattened beams as well as 6 MV FFF and 10 MV FFF beams. Dosimetric characteristics were summarized according to beam energy and parameter group. Comparability of dosimetric characteristics among linac models was evaluated using descriptive statistics and a predefined clinical criterion.

Results: We analyzed a total of 13 Agility-equipped Elekta linac models at 8 institutions, consisting of Versa HD (n = 7), Infinity (n = 5), and Synergy (n = 1) models. Most dosimetric parameters exhibited low variability, with coefficients of variation generally below 2% across evaluated beam energies. We incorporated data for the 6 FFF and 10 FFF beams into the updated dataset. Wedge factors exhibited the greatest variability among the evaluated parameters, with coefficients of variation up to 3.4%. We observed no clear dependence of wedge factors on beam energy or installation year.

Conclusions: Assessment of the dosimetric performance of Elekta linacs strengthens IROC's ability to provide accurate and targeted feedback to institutions receiving both on-site and virtual dosimetry review audits. In addition, the updated reference dosimetry dataset for Elekta linacs will provide institutions with a valuable quality assurance resource for independent dose verification of their clinical treatment systems. Caution is required when evaluating wedge factors as these show highly variable values.

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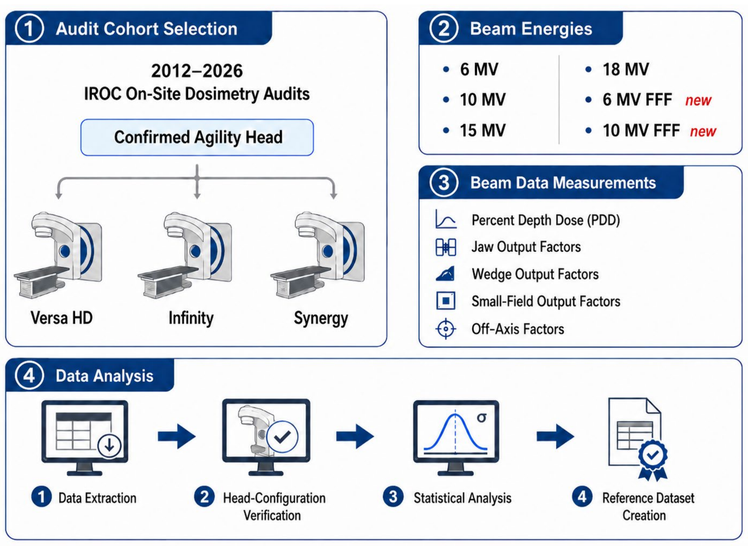
INTRODUCTION

- A standard dosimetry dataset for Elekta linear accelerators was previously published by Kerns et al. (2018), describing the expected dosimetric performance of these machines based on IROC's on-site dosimetry audits.
- This dosimetry dataset allows institutions to compare their own relative dosimetric measurements against IROC's data and serves as a reference dataset for virtual dosimetry audits performed by IROC globally.
- However, given the historic nature of the initial reference dataset and the rapid technological changes in radiotherapy, incorporating more recent results and newer machine types and novel radiotherapy beams is essential.
- **This work creates an updated reference photon dosimetry dataset for Agility-equipped Elekta linacs using IROC's on-site audit measurements, including those of flattening filter-free beams (FFF) that were not reported in the previously published Elekta reference dataset.**

METHODS



CONCLUSIONS

- We compiled and analyzed data from IROC site visits to create an updated reference photon dosimetry dataset for contemporary Elekta linacs with Agility head configurations.
- **This dataset may serve as a secondary check commissioning measurements and as a guide for understanding the expected variability of several critical parameters used in beam modeling.**
- Wedge factors exhibited the greatest variability among other evaluated test parameters and should receive particular attention during measurement, modeling, and validation.

REFERENCE

Kerns et al. Reference dosimetry data and modeling challenges for Elekta accelerators based on IROC Houston site visit data. Med. Phys. 2018; 45 (5).

RESULTS AND DISCUSSION

Table 1. Summary of the measured dosimetric parameters for Agility-equipped Elekta linacs by beam energy.

Beam Energy		6X (n=13)	6 FFF (n=8)	10X (n=11)	10 FFF (n=4)	15X (n=5)	18X (n=7)
	Depth						
PDD (10 x 10)	5 cm	0.871 (0.3%)	0.878 (0.7%)	0.908 (0.4%)	0.916 (0.3%)	0.934 (0.1%)	0.949 (0.5%)
	10 cm	0.677 (0.3%)	0.678 (0.6%)	0.726 (0.3%)	0.724 (0.1%)	0.757 (0.1%)	0.778 (0.4%)
	15 cm	0.518 (0.4%)	0.517 (0.7%)	0.575 (0.4%)	0.568 (0.2%)	0.610 (0.1%)	0.633 (0.4%)
	20 cm	0.396 (0.6%)	0.392 (0.7%)	0.454 (0.4%)	0.446 (0.5%)	0.491 (0.2%)	0.512 (0.4%)
Universal 60° (10 x 10)	10 cm	0.258 (3.0%)	N/A	0.271 (2.8%)	N/A	0.267 (1.2%)	0.260 (3.4%)
(15 x 15)	15 cm	0.268 (3.0%)	N/A	0.279 (2.7%)	N/A	0.274 (0.7%)	0.268 (3.1%)
	Field Size						
Jaw Output Factors	6x6 cm²	0.966 (0.4%)	0.977 (0.3%)	0.964 (0.5%)	0.975 (1.2%)	0.965 (0.2%)	0.956 (0.3%)
	15x15 cm²	1.032 (0.4%)	1.027 (0.6%)	1.035 (0.6%)	1.009 (0.4%)	1.033 (0.3%)	1.032 (0.2%)
	20x20 cm²	1.051 (0.6%)	1.034 (0.3%)	1.050 (0.5%)	1.016 (0.5%)	1.052 (0.6%)	1.052 (0.5%)
	30x30 cm²	1.071 (0.5%)	1.042 (0.2%)	1.071 (0.6%)	1.010 (1.0%)	1.072 (0.4%)	1.074 (0.5%)
Small-Field Output Factors	2x2 cm²	0.798 (0.5%)	0.821 (0.4%)	0.810 (0.5%)	0.835 (0.5%)	0.800 (0.4%)	0.793 (0.7%)
	3x3 cm²	0.842 (0.5%)	0.866 (0.4%)	0.863 (0.5%)	0.889 (0.5%)	0.865 (0.4%)	0.866 (0.4%)
	4x4 cm²	0.874 (0.3%)	0.897 (0.4%)	0.895 (0.3%)	0.922 (0.4%)	0.900 (0.3%)	0.906 (0.2%)
	6x6 cm²	0.926 (0.3%)	0.942 (0.2%)	0.939 (0.2%)	0.956 (0.2%)	0.945 (0.2%)	0.948 (0.1%)
	Off-Axis						
Off-Axis Output Factors	5 cm	1.024 (0.5%)	0.888 (0.7%)	1.028 (0.4%)	0.816 (0.8%)	1.033 (0.5%)	1.033 (0.8%)
	10 cm	1.050 (0.6%)	0.730 (0.6%)	1.046 (0.4%)	0.628 (1.3%)	1.060 (0.9%)	1.046 (0.9%)
	15 cm	1.054 (1.0%)	0.597 (1.2%)	1.053 (0.9%)	0.491 (1.1%)	1.080 (1.0%)	1.040 (1.2%)

Note: All data are median values; normalized to 10 x 10 cm²; corresponding coefficient of variations are given in parenthesis. n is the number of machines; N/A means that measurements are not available for that parameter.

Most dosimetric parameters showed low variability and similar performance, with coefficients of variation within ±2% across evaluated beam energies. **Wedge factors showed the greatest variability** among the evaluated parameters, **reaching up to 3.4%.**

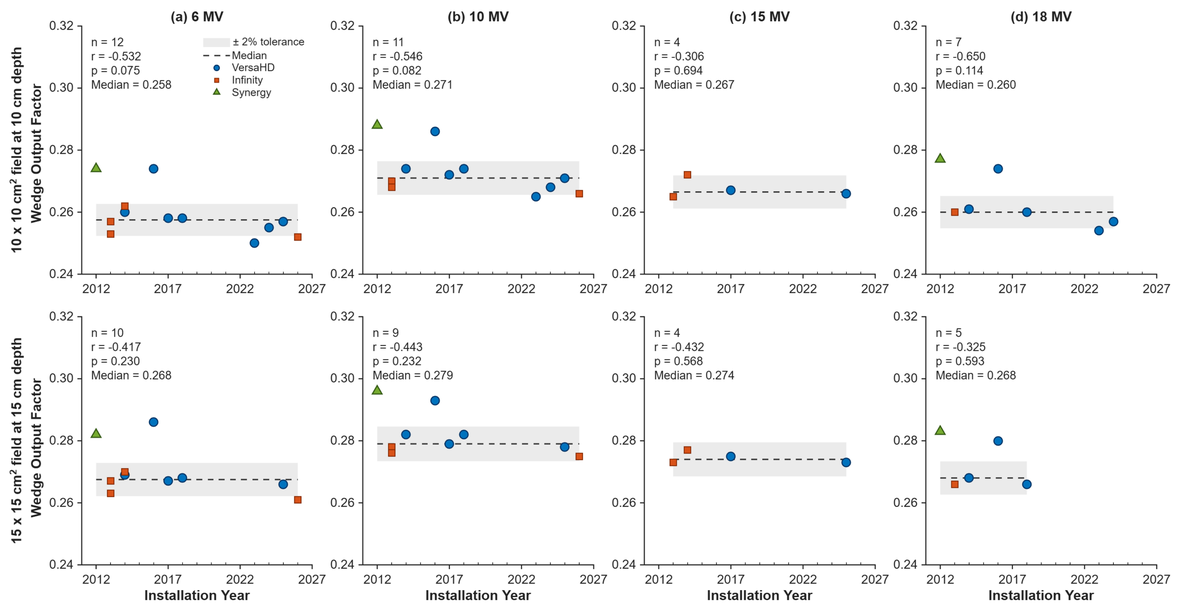


Figure 1. Wedge factors as a function of linac installation year for Agility-equipped Elekta linacs.

The 10 MV beam showed higher wedge factors compared with the other flattened beams. However, **wedge factors did not demonstrate a consistent dependence on beam energy or linac installation year.**