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Evaluation of absorbed dose uncertainty in modulated radiotherapy plans

Akademisk avhandling

som för avläggande av medicine doktorsexamen vid Sahlgrenska akademin, Göteborgs universitet, kommer att offentligen försvaras i Hjärtats aula, Vita Stråket 12, den 28 oktober, 2022, klockan 13:00

av **Julia Götstedt**

Fakultetsopponent: Professor Stine Sofia Korreman,
Institut for Klinisk Medicin, Aarhus Universitet, Århus, Danmark

Avhandlingen baseras på följande delarbeten

I. *IMRT patient-specific QA using Delta^4 dosimetry system and evaluation based on ICRU 83 recommendations*
Julia Nilsson, Anna Karlsson Hauer A and Anna Bäck
J. Phys.: Conf. Ser. 2013;444:012048

II. *Development and evaluation of aperture-based complexity metrics using film and EPID measurements of static MLC openings*
Julia Götstedt, Anna Karlsson Hauer and Anna Bäck
Med. Phys. 2015;42(7):3911-3921.

III. *Edge area metric complexity scoring of volumetric modulated arc therapy plans*
Julia Götstedt and Anna Bäck
Phys Imaging Radiat Oncol. 2021;17:124-129.

IV. *Evaluation of methods for dosimetric uncertainty assessment of VMAT plans*
Julia Götstedt, Anna Karlsson and Anna Bäck
In manuscript

SAHLGRENSKA AKADEMIN
INSTITUTIONEN FÖR KLINISKA VETENSKAPER

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Evaluation of absorbed dose uncertainty in modulated radiotherapy plans

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Abstract

The purpose of this work was to develop and evaluate methods to meet the challenges of quality control (QC) for modulated radiotherapy plans. It was shown that nine of 15 intensity modulated radiotherapy (IMRT) plans, with deliberately introduced dose errors larger than 5% in at least one evaluated dose volume histogram (DVH) metric, were not detected with a QC method which combined Delta^4 (ScandiDos) measurements and internationally recommended criteria for evaluation (**Paper I**). The dose difference between calculation and high spatial resolution measurements, using EBT3 film and electronic portal imaging device (EPID), for 30 static beam apertures of varying size and shape was used as a measure of beam aperture complexity (**Paper II**). The linear correlation to the beam aperture complexity was evaluated for three aperture-based complexity metrics developed in this study and five other metrics suggested in the literature. The strongest correlation, with a Pearson's r-value of -0.94, was found for the developed edge area metric (EAM). EAM was further evaluated for 18 static beam openings originating from control points of clinically used volumetric modulated arc therapy (VMAT) plans and for 200 full VMAT plans planned for different treatment sites (**Paper III**). The results indicated that the EAM must be interpreted differently for different diagnoses. Evaluation of beam aperture shape, modulation variations, measurements, and delivery simulations, as methods for assessment of the dosimetric uncertainty for VMAT plans, showed that the dosimetric uncertainty could differ even though the plans appeared to be equal based solely on dosimetric comparisons of the dose distributions, e.g., DVH metric evaluations (**Paper IV**).

In conclusion, it is possible to decrease dosimetric uncertainties in modulated radiotherapy plans to enable a higher treatment quality. The dosimetric uncertainties can be assessed by different methods but it is important to define the purpose of the method, and to validate that the method fulfils the defined purpose.

Keywords: Modulated radiotherapy, dosimetric uncertainty, quality control (QC), quality assurance (QA), complexity metric, edge area metric (EAM)

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