The influence of the bow tie filtration on the dose and image quality for the Elekta XVI coneBeam CT

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Introduction

Cone Beam Computer Tomography (CBCT) is used to control the position of the patient based on internal body structures. Thereby, the CBCT data set is fitted to the planning CT image. The accuracy of this alignment process strongly depends on the quality of the CBCT images. The radiotherapy department of the cantonal hospital St.Gallen operates two Elekta Synergy linacs equipped with an integrated CBCT. One linac is equipped with a bowtie filter which reduces the dose originating from the body surface and, in this way, reduces image artefacts. It was the aim of the presented study to evaluate the influence of the bowtie filter on the image quality and the dose to the patient.

Material and Methods

Image acquisitions have been performed without and with the bowtie filter (mAs product l.6 times larger than without filtration). For the dose measurements, CBCT images have been acquired using CT body and head phantoms (Capintec, INC, NJ, USA). Three different collimators have been applied: M10 (∅ = 41.7 cm, length = 13.5 cm); S20 (∅ = 27.4 cm, length = 27.7 cm); L20 (∅ = 50.7 cm, length = 27.7 cm). The dose measurements have been performed in the centre (D_c) and in four peripheral positions ($D_{p,i}$, i = 1...4) with a PTW31003 chamber and the PTW Unidos electrometer (PTW Freiburg). The CT dose index (CTDI) has been calculated based on the expressions
$CTDI = 1/3 \times (D_c + 2/3 \times D_p)$; $D_p = ¼ \times (D_{p,1} + D_{p,2} + D_{p,3} + D_{p,4})$.
For the determination of the image resolution, the CatPhan 500 CT phantom (The Phantom Laboratory, NY, USA) and the module CTP 528 (provided with line patterns showing 1 to 21 lines per cm) have been used. The modulation transfer function (MTF) has been derived as described by [1]. The homogeneity has been investigated by evaluating concentric 5 mm rings. Additionally, acquisitions of an Alderson Phantom (RSD, INC, CA, USA) have been evaluated.

Results

The CTDI values are summarized in table 1.

	without filter	with filter	ratio
S20	$(1.10 \pm 0.03) \cdot 10^{-3}$ Gy	$(1.26 \pm 0.03) \cdot 10^{-3}$ Gy	114.1%
M10	$(2.99 \pm 0.03) \cdot 10^{-2}$ Gy	$(2.94 \pm 0.03) \cdot 10^{-2}$ Gy	98.5 %
L20	$(1.22 \pm 0.01) \cdot 10^{-2}$ Gy	$(1.14 \pm 0.01) \cdot 10^{-2}$ Gy	93.6 %

Table 1.: CTDI values for different collimators, with and without bowtie filter

The bowtie filter has no apparent influence on the image resolution. Only for the S20 collimator, the MTF shows larger values (for 5 to 9 lines per cm) than without filtration. The surface of the Capintec phantom, acquired with the bowtie filter, shows a sharper edge but also artefacts in the air due to an overcompensation effect. This is valid for all tested collimators, but more pronounced for larger collimators. The same observation can be done with the Alderson phantom. See further results in [2].

Discussion

The influence of the bowtie filter on the applied dose is clearly smaller than 20 %. While the resolution is not affected markedly, the image quality is better especially for larger collimators.

References

[1] Ronald T. Droege and Richard L. Morin. A practical method to measure the MTF of CT scanners. Med. Phys., 9 (5):758–760, 1982.
[2] Lukas Wissmann. Einfluss von Bow-Tie-Filtration auf Dosis und Bildqualität beim Elekta XVI ConeBeam CT. Term paper, ETH Zürich, 2009.