Experimental Study on the Performance of the OMAR CT Artifact Correction Algorithm Near Titanium and Stainless Steel

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Purpose:
Implants with high atomic numbers produce star-like artifacts in CT-images. When coupled in pairs, a black window appears in between. The Philips OMAR algorithm approaches these artifacts by post processing the images. In this study, measurements were performed with radiochromic EBT2 films[1] in order to verify, whether the OMAR algorithm contributes to the accuracy of treatment plans in implant regions.

Methods: Two sets of titanium and stainless steel rods with diameters of 1” and ½” were centered in a water phantom either single or in pairs. The phantom was scanned in a Philips Bigbore Brilliance scanner, which provides the OMAR correction algorithm. A set of uncorrected CT data was kept in addition to the post processed data.
The treatment plans were calculated with AAA in Eclipse (fig. 1). The Hounsfield units in the volume of the metal rods were set to match the relative electron density of the metals and the conversion table extended accordingly. A 10x12 field at 90 degrees gantry rotation and 400MU was calculated using on a 1mm grid. The plans were irradiated using a Varian Novalis-TX linac with EBT3 films placed on the sides of the single rod setup or between the rods in the two rod setups. The FilmQA Pro Software was used for evaluation of the films[1].

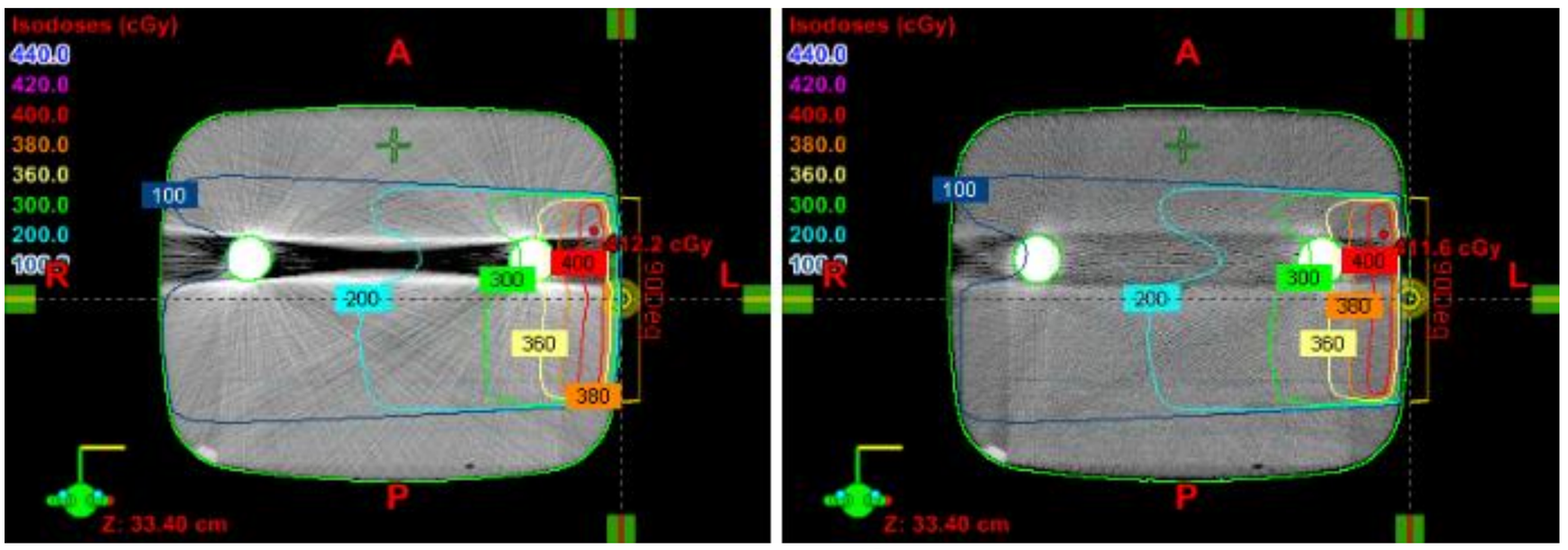

Figure 1: A sectional view of the uncorrected CT data of a phantom scan with one centered 1” titanium rod is shown on the left and the OMAR corrected CT data is shown on the right. The film was placed in the plane between the rods. The rod had been contoured and the hounsfield units set according to the conversion table used by Eclipse (AAA). A rectangular field with 400MUs was planned on a 1mm grid and irradiated on a Varian Novalis TX linac.

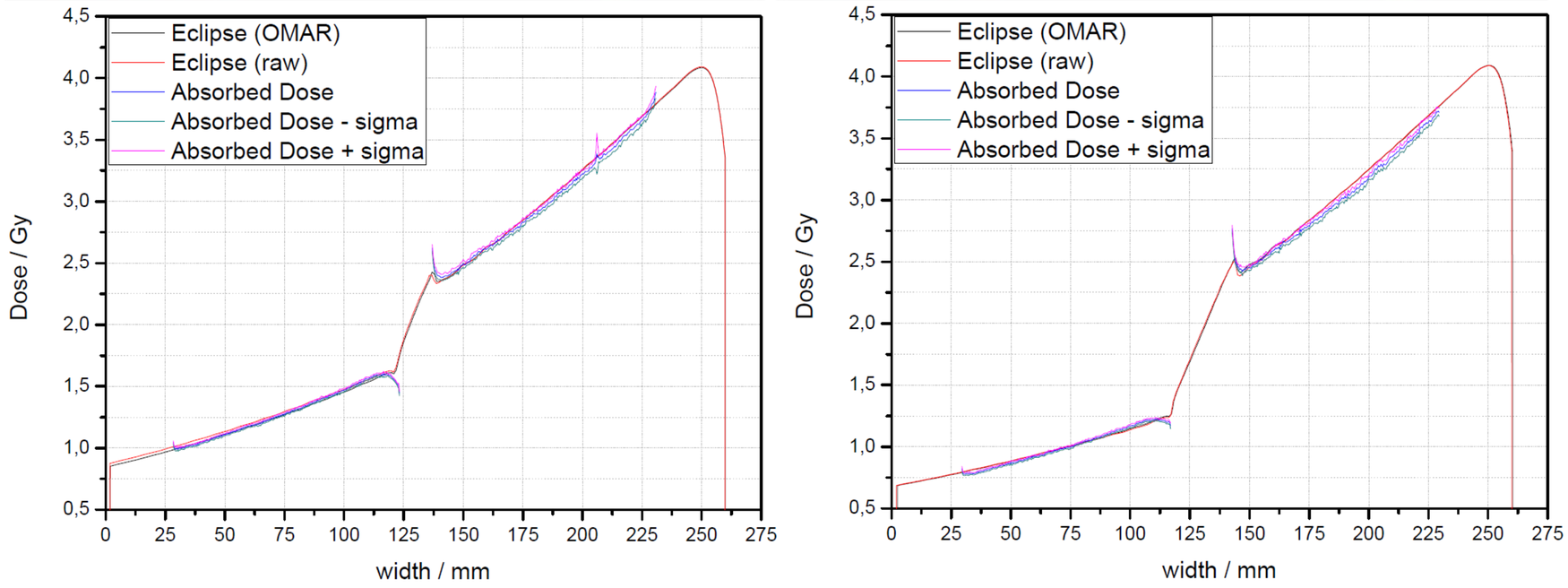

Figure 2: The measurements and calculated dose profiles of the setup with centered metal rods. The left graph shows the 1/2” 316 stainless steel rod and right graph the 1” 316 stainless steel rod. No significant difference can be seen between the calculated dose based on raw or OMAR post processed data, when only one rod is present in the phantom. AAA does not account for backscattering from the high Z material, nor does it consider the repeated build-up behind the high Z material.

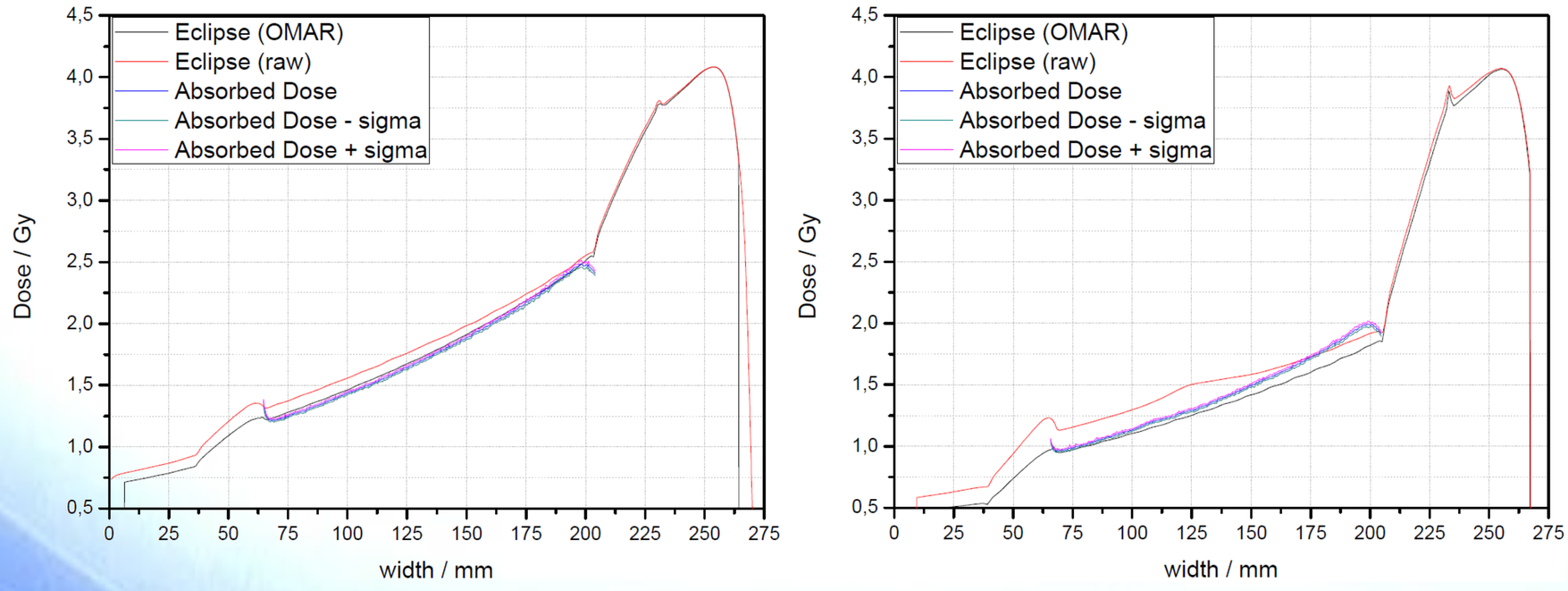

Figure 3: The setups with two rods show significant differences in calculated dose distribution between the post processed and unprocessed CT data. The film measurement and the AAA calculated dose based on the OMAR corrected CT data matches. This is shown on the left. Since the significance of repeated build-up effect[2] increases with the atomic number of the absorber, this is not true for 316 stainless steel, which is shown on the right.

Results: With one inhomogeneity present in the phantom, the difference between the plans based on the uncorrected data and the plans based on the post processed data is small (fig. 2). With paired inhomogeneities and the associated increased artifact, the difference becomes more significant and the OMAR algorithm improves the accuracy. High Z scattering effects cause considerable deviation from the planned dose profiles near the rods (fig. 3).

Conclusion: The OMAR-algorithm improves the accuracy of the dose calculations. The dose profiles across implant regions are calculated accurately, if the Hounsfield units are defined accordingly.

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1) Gafchromic EBT2 and FilmQA Pro, www.filmqapro.com
2) Reft et al., „Dosimetric considerations for patients with HIP prostheses undergoing pelvic irradiation. Report of the AAPM Radiation Therapy Committee Task Group 63.“ Med. Phys. 30 .6., June 2003