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Dose Calculation Inaccuracy in the Presence of Backscattered and Forward Scattered Electrons from Implants used in Current Dental Practice

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INTRODUCTION/PURPOSE

- Patients being treated for head and neck cancers frequently have different types of implanted dental hardware.
- The aim of the work is to quantify the errors in two widely used dose calculation algorithms of Eclipse Analytic Anisotropic Algorithm (AAA) and Acuros XB (AXB) with 6 MV beams in the immediate vicinity of metallic and nonmetallic dental implants used in current dental practice.

METHOD

Five dental rectangular samples composed of Titanium (Acnis), Cobalt Chromium (MESA), Zirconium (Nacera), Peek (Juvora) and Pekton (Cendres + Metaus) sized 24 x 24 x 2mm were studied. (Fig.1)

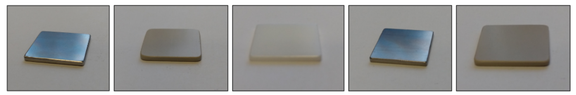
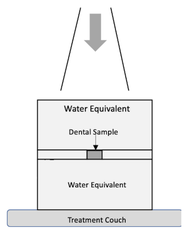
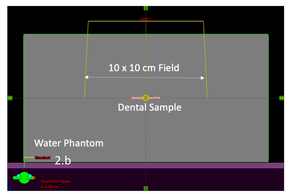


Fig 1. Titanium (1.a), Pekton (1.b), Zirconium (1.c), Cobalt Chromium(1.d) and Peek (1.e) dental specimens.

- Dental samples were placed with their centers at isocenter at a depth of 5 cm in a phantom approximately 25cm x 25 cm x 10cm.
- Dose profiles were determined with radiochromic EBT3 film placed in contact with specimen top and bottom, 1mm in upstream, and 1, 4 and 9mm downstream. The film was placed in a coronal plane.

Fig 2(a) illustrates the measurement setup with EBT3 radiochromic film and dental implants , fig.2(b) illustrates corresponding calculation setup in eclipse for AAA and AXB calculations.





- The phantom was irradiated with 6 MV beam from a Truebeam linac (Varian Medical Systems). A radiation dose of 450 cGy were delivered with field size of 10×10 cm, and water phantom surface set to 94.9 cm SSD.
- The setup was modeled in Eclipse. AAA and Acuros XB were used to determine dose distributions at the different depths.
- For each film exposure with the hardware, a second film was exposed without the hardware present.
- The dose ratios (hardware / no hardware) were computed

RESULTS

Fig 3. Profiles of dose ratios (implant / no implant) at different depths for Titanium determined using film, AAA and AXB.

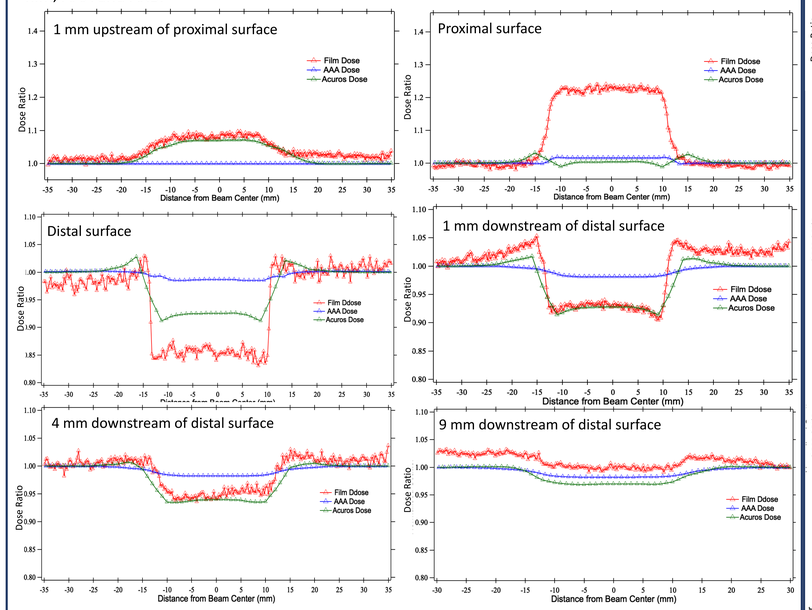
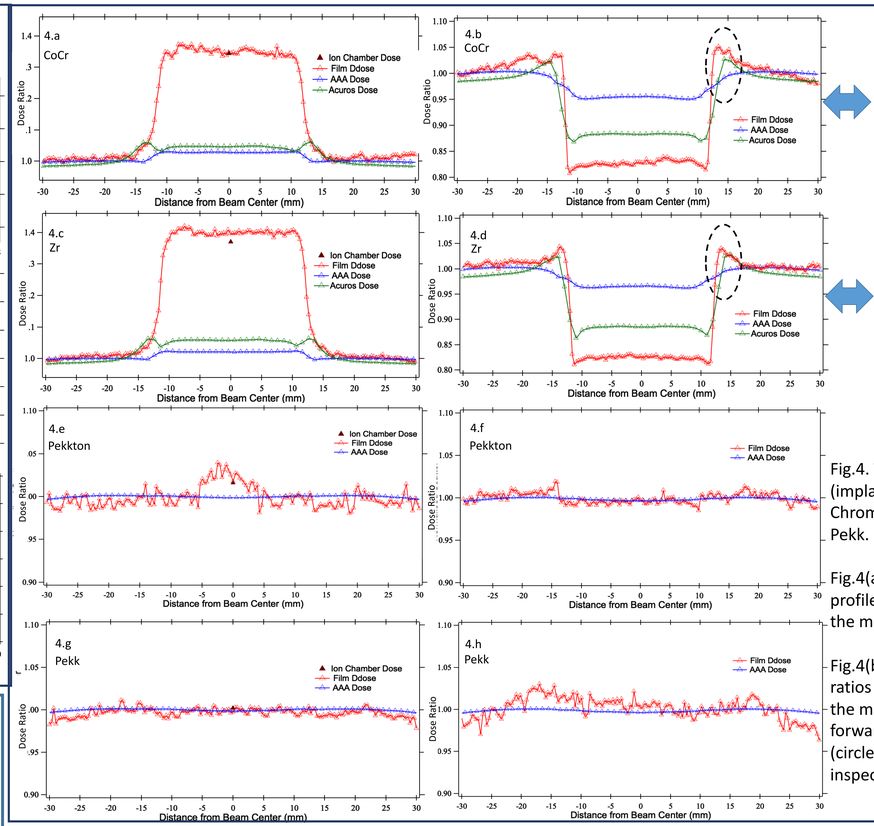


Table 1. The upstream surface dose ratios (backscatter), downstream surface dose ratios (forward scatter+transmission) and side scatter for the 5 materials, and the corresponding percent errors for the AAA and AXB algorithms

Material	Relative Electron Density	Physical Density	Backscatter	AAA % Error	AXB % Error	% Sidescatter	Transmission + Forward scatter	AAA % Error	AXB % Error
Zirconium	5.88	7.07	1.389	36.9	32	4.1	0.826	16.95	7.3
Cobalt Chromium	6.66	8	1.344	30.7	28.5	5.1	0.829	15.31	8.3
Titanium	3.73	4.51	1.232	23.18	20.48	3.8	0.84	17	3.5
PEKKTON	1.26	1.31	1.016	1.7			0.998	0.1	
PEKK	1.26	1.31	1.002	0.3			1.005	0.8	



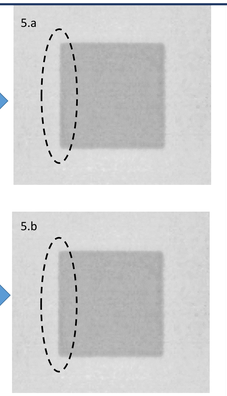


Fig.4. The dose profile ratios (implant / no implant) for Cobalt Chromium, Zirconium, Pekkton & Pekk.

Fig.4(a), (c), (e) & (g) are the profile ratios immediately above the material (backscatter)

Fig.4(b), (d),(f) & (h) are the profile ratios immediately downstream of the material Also apparent is forward-directed side scatter (circled) that can be seen by visual inspection of the films. (Fig. 5)

- Dose increase at the upstream interface (backscatter) ranged from 39-23% for metallic materials and was negligible for nonmetallic materials.
- Dose enhancement due to forward side scatter was small, 4-5%, with metallic materials, and negligible for non-metallics.
- AAA and AXB had comparable backscatter dose discrepancy relative to EBT3 film measurements, ranging from 20-37% at the upstream metallic interfaces.
- At the downstream metallic interfaces, the maximum dose discrepancy when compared with film ranged from 3.5-7.3% for AXB and 15-17% for AAA.

CONCLUSIONS

- The effect of dental implants on the dose distributions of the 6 MV beam commonly used in head and neck radiotherapy were investigated.
- Dose measurements in close proximity to materials used in current dental practice, both upstream and downstream on an incident 6 MV beam were made using radiochromic film. The results were compared with calculations using two commonly used algorithms AAA and AXB.
- Metallic dental hardware cause significant dose perturbations compared to nonmetallic polymer implants.
- Acuros XB modelled scatter and transmitted dose distributions accurately compared to AAA.

REFERENCES

1. Azizi M, et.al. Dosimetric evaluation of scattered and attenuated radiation due to dental restorations in head and neck radiotherapy. *J Radiat Res Appl Sci*. 2018; **11**: 23– 28

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