Dose enhancement measurements at high-Z dental materials using radiochromic EBT-2 films

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Purpose

The purpose of this work is to investigate the dose enhancement at high-Z interfaces using radiochromic EBT2 films. This phenomenon typically occurs during radiotherapy in the H&N region at the interfaces of dental crowns and implants. The dose enhancement caused may result in necrosis of tissue or damage to the jawbone. The magnitude of dose enhancement due to typical dental crown materials was investigated in this study.

Materials: The dose enhancement effect was investigated for the following materials:

- **Dental gold alloy**
  73% gold, 16% aurum, 11% other
- **Cobalt-chromium alloy**
  61% cobalt, 29% chromium, 10% other
- **Zirconium dioxide (unsintered)**
  stabilized with 5% Y_2O_3
- **Titanium**

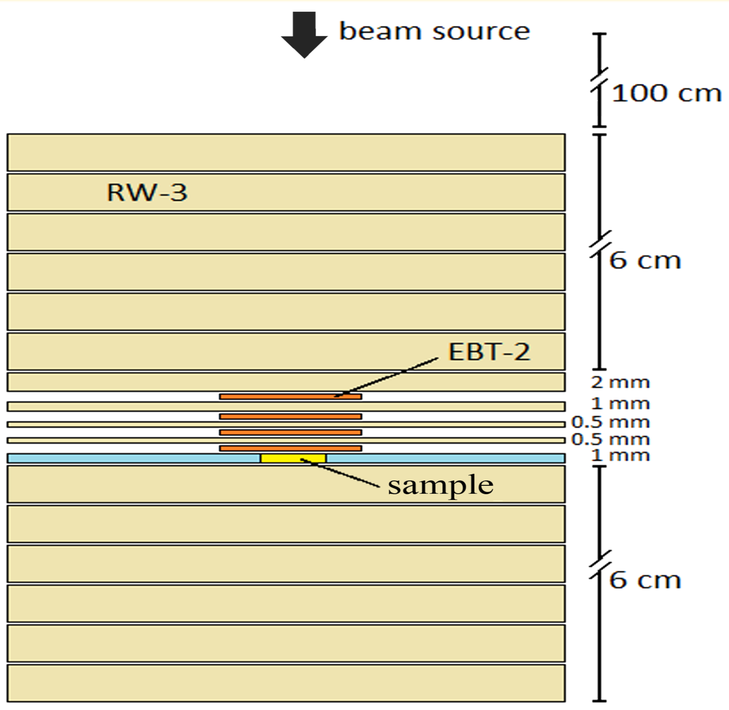

Figure 1: The top-stacked setup used to investigate the proximal dose distribution

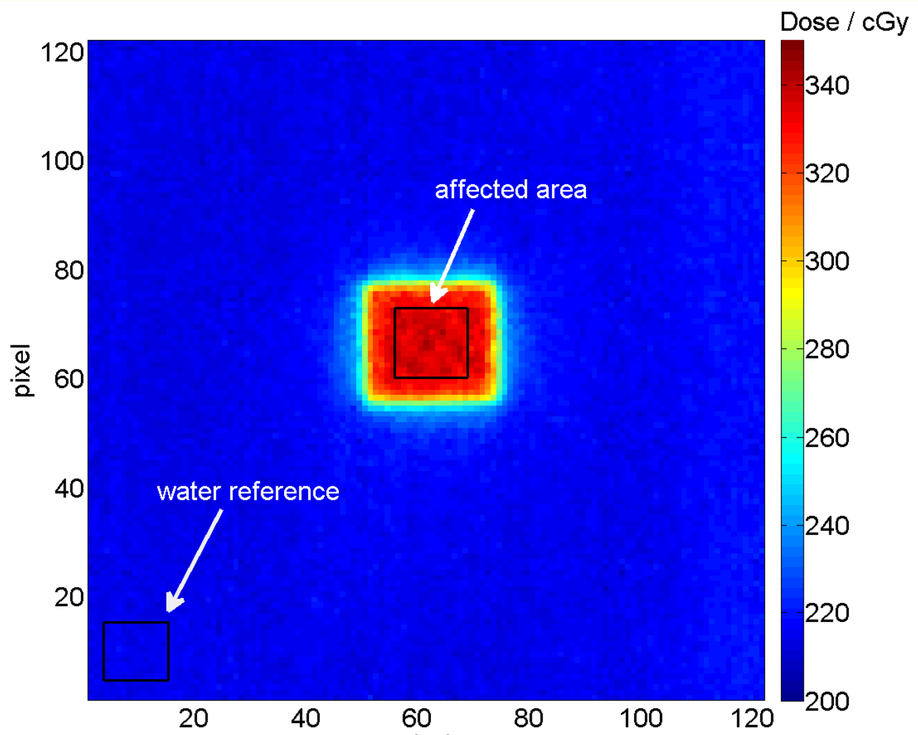

Figure 2: Dose enhancement on dental gold at a proximal distance of 221µm.

Setup: The proximal dose distribution was measured in a setup according to Figure 1. An inverse setup was used to investigate the distal dose distribution.

Irradiation: At a Siemens Primus linac, a 6MV photon beam with a field size of 10x10cm² and a source to surface distance of 100cm was used. Each setup was irradiated with 200MUs.

Calibration: Seven calibration films were irradiated in a separate measurement series accompanying each investigation. The calibration function was determined using a 2nd degree polynomial fit. A type 31013 ionization chamber (PTW) with a volume of 0.3 cm³ was used as reference for absolute dose calibration.

Digitization: The EBT2 films were digitized 24 hours after irradiation using an Epson 10000 XL scanner with a transparency unit and a scanning resolution of 72dpi. The films were fixed with a frame to prevent interference patterns[1] (Newton rings) on scanned images and to ensure reproducible positioning of the films on the scanning bed.

Analysis: The scanned images were analyzed using Matlab (*The MathWorks* Inc, Natick, MA). Prior to evaluation, a film uniformity error correction algorithm[2] and the calibration function were applied to all images. A distant area on the image was chosen as water reference while the dose values at other positions were divided by this water reference. The ratio of material sample area and water reference area is the dose enhancement factor.

Results

The dose enhancement at the proximal surfaces of the samples are shown in table 1. The results were verified with Monte Carlo simulations using DOSRZnrc/EGSnrc[3]. In all cases, the dose enhancement decreases to less than 10% at a proximal distance of 3mm.

Distance / mm	Dental gold	Wirobond	Zirconium Dioxide	Titanium
0.2	59%	25%	26%	21%
1.1	30%	13%	13%	4%
1.9	18%	3%	9%	1%
3.3	7%	0%	2%	1%

Table 1: Dose enhancement near the proximal surfaces

Conclusion

The dose enhancement near dental implant materials is significant and should be properly accounted for in treatment plans and, if possible, a safety distance should be created around crowns with approximately 3mm of water equivalent material.

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Literature:
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2. Kairn T, Aland T, Kenny J 2010 Some EBT2 problems solved *Phys. Med. Biol.* 55(15): L37-L42
3. Kawrakow and Rogers 2003 NRCC Report PIRS-701, Ottawa