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PRESENTATION TITLE

Dosimetric feasibility of on-body receive array placement to enhance image quality in the MR-linac

AUTHOR(S)

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ABSTRACT

Dosimetric feasibility of on-body receive array placement to enhance image quality in the MR-linac

Purpose

The current MR-linac anterior and posterior receive arrays contain four channels each. The anterior array is elevated above the patient using a coil bridge. To increase the image quality and speed in the MR-linac, we are developing a new 64-channel receive array, which will be placed directly onto the patient. Consequently, more secondary electrons that originate from the copper and plastic will reach the skin.[1] In this work we assess the dosimetric impact of various coil materials and optimize the radiolucent design of the receive array in the MR-linac.

Methods

Prototypes were created with five layers: leather, plastic support, copper loops, foam, and leather again. The low (electron) density foam serves as a spacer between the material with high electron density (i.e., copper and plastic) and the patient surface to reduce skin dose. There is, however, a tradeoff: a larger foam thickness results in a larger coil-to-body distance at the expense of imaging performance.

Optimal foam thickness: multiple 1×2 element array prototypes with foam thicknesses ranging from 4 to 15 mm were irradiated with a 250 MU, 22×56 cm^2 field on a 1.5T MR-linac (Unity, Elekta AB, Stockholm) (Figure 1a,b). Dosimetry was performed using GAFCHROMIC (Ashland, Bridgewater, NJ) EBT3 films. Doses were measured without the coils (D_{open}) and with the coils placed directly onto the film (D_{coil}).

Depth-dose information: based on the initial results, a 2×2 element array prototype with 15 mm foam was built. A vertically positioned film between blocks of solid water was irradiated with a 500 MU, 10×10 cm^2 field with and without a coil present (Figure 2a). Depth-dose curves were generated by averaging 200 lines in the center of the beam profile (Figure 2b).

Results

An increased foam thickness decreases the surface dose (Figure 1c), from a mean dose of 89.1±6.1 cGy with visible loop imprints using 4 mm thick foam to 54.9±3.1 cGy without loop imprints using 15 mm. The latter amounts to an increase from $0.20D_{max}$ (D_{open}) to $0.34D_{max}$ ($D_{coil,15mm}$).

The depth-dose curves with and without the coil (Figure 2c) show maximal dose differences of 17.9 cGy ($<0.04D_{max}$) in the build-up region. Accurate surface doses could not be obtained in this setup. From a depth of 1 cm the curves overlap.

Discussion and conclusion

The use of 15 mm foam resulted in the lowest surface dose, i.e. $0.34D_{max}$. To put this into perspective, the current treatment table causes surface doses of up to $1.35D_{max}$ (results not shown).

Dose increases in the depth-dose curves of <5% before D_{max} and the lack of dose difference at depths greater than 1 cm suggest that on-body placement of a receive array during a treatment in the MR-linac is feasible. This has distinct advantages for our 64-channel array in terms of imaging performance and acceleration, which are needed for real-time imaging during treatment.

Acknowledgements

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References

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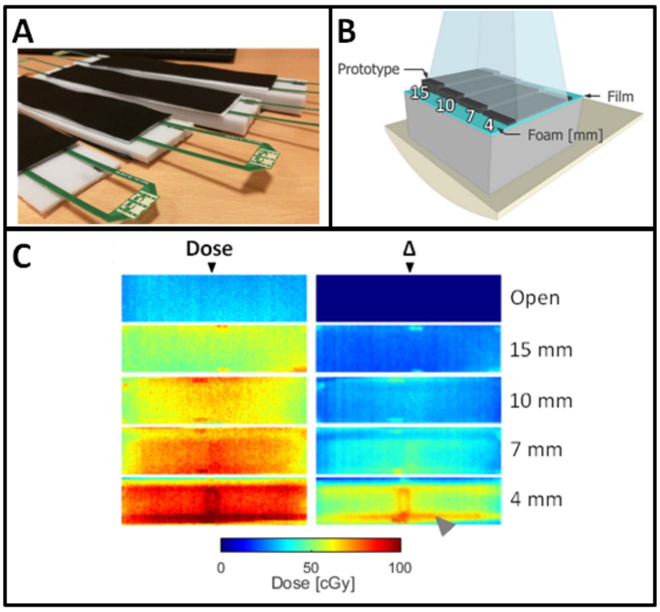

Figure 1. (a) Photo of the four array prototypes with varying foam thicknesses. (b) Experimental setup of foam thickness optimization. A film is placed on a solid water volume and irradiated from gantry angle 0°. Two films are irradiated, one with (D_{coil}) and one without (D_{open}) four array prototypes. (c) Left row: the delivered dose per prototype. Right row: dose difference Δ with respect to D_{open}. Note that for 4 mm thickness the coil imprint is visible (gray arrow).

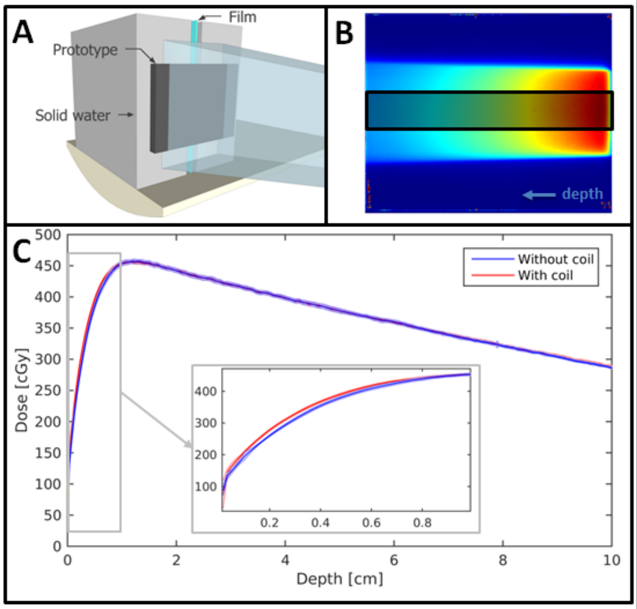

Figure 2. (a) Experimental setup for obtaining depth-dose information. A 10×10 cm 2 beam from 90° was repeated with and without prototype. (b) The resulting films were converted to depth-dose curves by averaging 200 lines. (c) Depth-dose curves with and without prototype.