

Characterization of tissue optical properties for total skin electron treatment (TSET) patients using multifiber diffuse reflectance spectroscopy system

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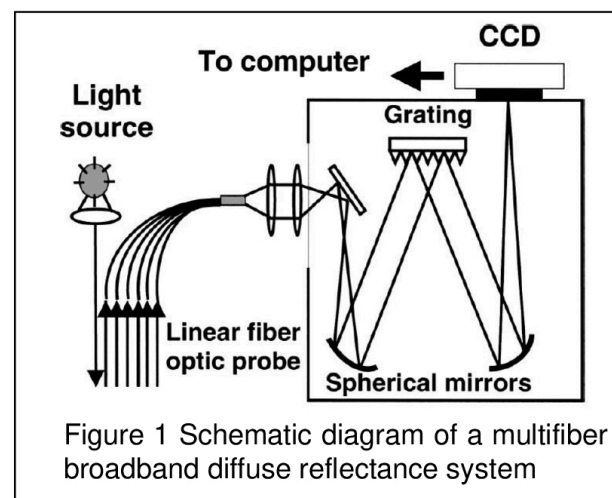
Introduction

Radiation dose deposition on patient during electron therapy can be visualized by imaging of Cherenkov emission from tissue surface. The implementation of Cherenkov imaging offers an excellent technology to detect abnormalities in the treatment, which would otherwise go unnoticed. However, spatial heterogeneity in optical properties due to different tissue sites, skin pigmentation and discoloration, is commonly encountered in patients and may easily be misinterpreted as non-uniformity of dose deposition if this is not corrected for carefully. Besides intra-patient heterogeneity, optical properties of human tissues can vary greatly across patients. Thus, accurate knowledge of spatial variations in tissue optical properties is important to correct for the alteration in Cherenkov intensity and allow for accurate visualization of radiation dose deposition.

In this study, we employed a multifiber diffuse reflectance spectroscopy system to determine spatial variations in the tissue optical properties, namely absorption (μ_a) and reduced scattering coefficients (μ'_s), at 650nm on various body parts of 14 patients receiving TSET.

Methods

Diffuse reflectance measurements were acquired before TSET treatment using a specially designed fiber optic-based contact probe consisting of one source fiber, coupled to an air-cooled quartz-tungsten-halogen (QTH) lamp (Avalight HAL-S, Avantes, Inc., Louisville, CO, USA), and 9 detection fibers spaced at distances from 1.4 to 8.7 mm from the source. Measurements were made with the probe in contact with the tissue surface at multiple body locations, including arm, leg and chest. Measurements were also made at neck, forehead and cheek in some patients and the results were presented in this paper.



The reflected light was collected by the detection fibers which are imaged via a spectrograph onto a CCD, to measure radially-resolved diffuse reflectance. Background signal was measured in the same tissue with the white light source turned off, and then subtracted from each measurement. Each tissue spectrum is divided by the spectrum obtained with the same light source and detector in an integrating sphere to account for the wavelength-dependence of the white light source power and CCD response. The diffuse reflectance spectra are fitted with a using a wavelength-wise fitting method, based on the hybrid P3 approximation developed by Hull and Foster [1], to extract tissue optical properties at 650nm. Absorption and reduced scattering coefficients for 14 patients measured between February of 2018 and September of 2019, were reported.

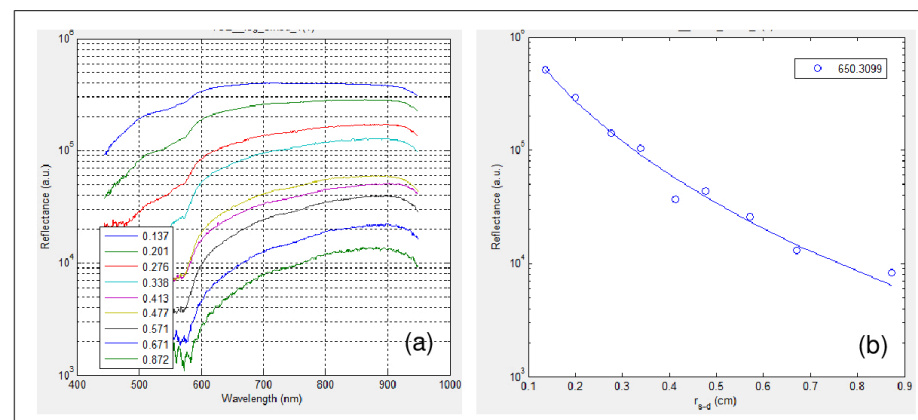


Figure 2 (a) Example of broadband reflectance spectra taken using the multifiber contact probe from the leg of patient #10. (b) The fit of reflectance at 650 nm using hybrid P3 approximation model.

Results

Table 1 Absorption coefficients, μ_a (cm^{-1}) at 650 nm for 14 patients.

Patient	Arm	Leg	Chest	Neck	Cheek	Forehead
#7	0.44	0.29	0.36	0.19	-	-
#8	0.15	0.16	0.25	0.23	-	-
#9	0.09	0.04	0.06	-	-	-
#10	0.23	0.16	0.12	-	-	-
#11	-	-	-	0.23	0.38	0.18
#12	0.13	0.11	0.15	-	-	-
#13	0.10	0.14	0.13	-	-	-
#14	0.04	0.16	0.06	-	-	-
#15	0.17	0.16	0.18	-	-	-
#17	0.10	0.07	0.08	-	-	-
#18	0.29	0.22	0.15	-	-	-
#20	0.15	0.20	0.18	-	-	-
#21	0.10	0.11	0.09	-	-	-
#22	0.09	0.22	0.17	-	-	-
Average	0.16	0.16	0.15	0.22	0.38	0.18
Standard deviation	0.10	0.06	0.08	0.02	-	-

Table 2 Reduced scattering coefficients, μ'_s (cm^{-1}) at 650 nm for 14 patients.

Patient	Arm	Leg	Chest	Neck	Cheek	Forehead
#7	17.6	16.9	16.9	13.8	-	-
#8	13.3	15.6	15.9	16.4	-	-
#9	19.4	20.8	19.2	-	-	-
#10	13.4	15.2	14.4	-	-	-
#11	-	-	-	24.3	22	19.7
#12	11.5	12.7	12.9	-	-	-
#13	8.1	9.6	19.6	-	-	-
#14	13.1	13.4	19.7	-	-	-
#15	14.1	15.4	25.1	-	-	-
#17	12.8	23.6	10.5	-	-	-
#18	16.7	15.8	16.6	-	-	-
#20	14.5	14.8	16.4	-	-	-
#21	11.6	16.1	18.2	-	-	-
#22	19.2	17.3	16.5	-	-	-
Average	14.3	15.9	17.1	18.2	22	19.7
Standard deviation	3.1	3.3	3.4	4.5	-	-

Conclusion

We demonstrated measurements of tissue optical properties using a multifiber diffuse reflectance spectroscopy system from TSET patients. The average absorption and reduced scattering coefficients measured at various body parts of 14 patients are $0.17 \pm 0.09 \text{ cm}^{-1}$ and $16.2 \pm 3.7 \text{ cm}^{-1}$, respectively.

Acknowledgements

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References

[1] Hull, E.L. et. al., JOSA A, 18(3), 584-599 (2001).

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