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Effect of light tip optical design on dental radiometer accuracy

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Introduction: Dental radiometers (DRs) vary widely in accuracy for some light curing units (LCUs) mainly because of sensor and aperture size, filters and spectral responsivity. A new hypothesis is that LCU tip design; Type I (fiber-bundle light guide) or Type II (light source at tip; (Figure 1) can influence the accuracy of DRs.

Aims: To compare current commercial DRs and a prototype device (checkUP, BlueLight Analytics, Canada) with absolute measurements derived from a 'gold-standard' (GS) integrating sphere assembly.

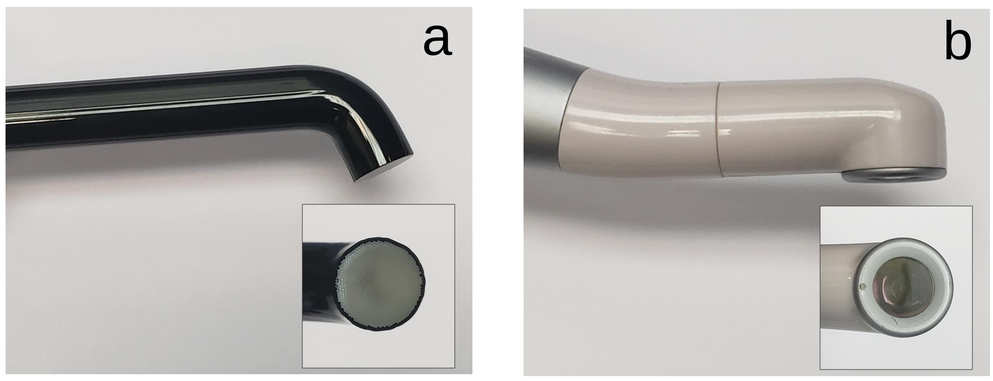

Figure 1^: An example of the difference in tip geometries of, (a) Type I, and (b) Type II LCU.

Methods: The irradiance of Type I and Type II LED LCU models were measured using up to 16 commercial DRs and the prototype device. GS irradiance values were derived from power measurements made with a laboratory grade integrating sphere and fiber-optic coupled spectrometer setup. Data sets were analyzed with standard parametric (GLM ANOVA) and non-parametric (Kruskal-Wallis and Mann Whitney U) test methods (p=0.05). Irradiance results from the DRs and checkUP were normalized relative to GS data for comparison purposes.

LCU (mode)	Type	checkUP	Kerr LED	S.D.I.	Bluephase MI	Bluephase MII	LM-1
BA Ultimate	I	0.4	41.4	15.6	28.4	3.5	17.9
Bluephase 16i (High)	I	1.0	30.2	13.2	0.2	12.9	8.6
Bluephase 20i (High)	I	2.3	34.3	18.8	0.2	10.0	10.5
Bluephase 20i (Turbo)	I	5.5	34.9	11.4	2.0	13.2	11.9
Bluephase 20i (Low)	I	2.3	44.1	43.1	5.4	8.3	28.9
Bluephase Style	I	0.6	32.4	0.7	0.9	6.4	21.3
Bluephase Style M8	I	4.4	21.0	23.6	14.0	2.2	49.9
Cybird	I	2.5	30.3	100.0	3.3	2.9	25.0
Elipar DeepCure	I	2.1	12.0	28.9	14.7	11.2	39.5
Elipar S10	I	2.8	14.3	39.3	10.8	12.6	47.9
Translux2Wave (Stand.)	I	4.4	34.9	11.1	5.1	9.1	3.4
Demi Ultra	II	1.2	26.4	8.8	33.9	4.8	34.7
Pencure VII	II	0.7	10.0	35.3	24.0	53.6	68.6
Radii Plus (Stand.)	II	0.2	39.7	62.3	64.6	22.4	0.9
SmartLite Focus	II	0.7	22.3	12.7	41.4	13.7	41.7
Valo Grand (High)	II	2.2	14.3	22.9	16.7	22.7	28.5

Table^: Percentage (%) difference irradiance values (relative to the integrating sphere (GS) data) of nine Type I and five Type II LED LCU models using five commercial DRs and checkUP.

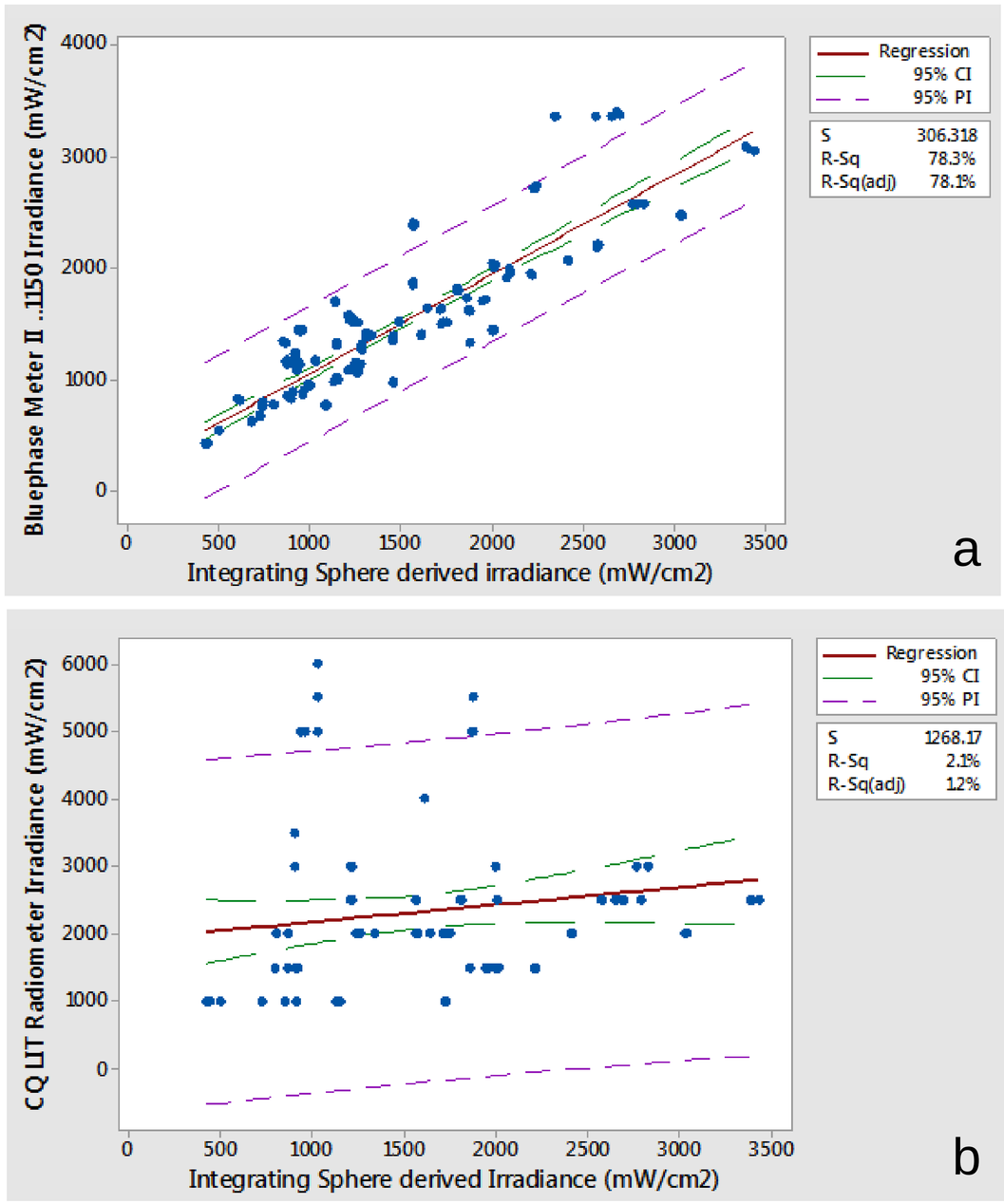

Figure 2^: Regression analysis fitted line plots comparing irradiance data (combined, 38 Type I and Type II LCUs) for (a) Bluephase 2, and (b) CQ LIT DR with the corresponding Integrating Sphere derived irradiance data sets as the independent variable.

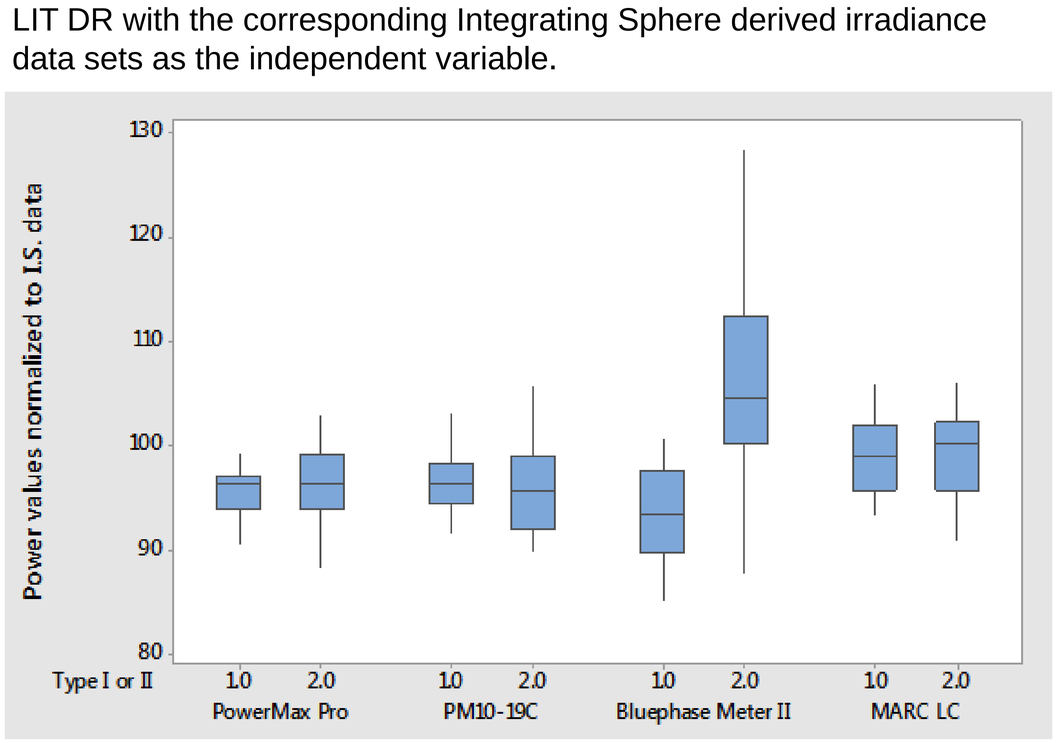

Figure 3^: Pooled normalized mean power readings for 19 Type I and 19 Type II LCUs relative to the integrating sphere (GS) data 100% values

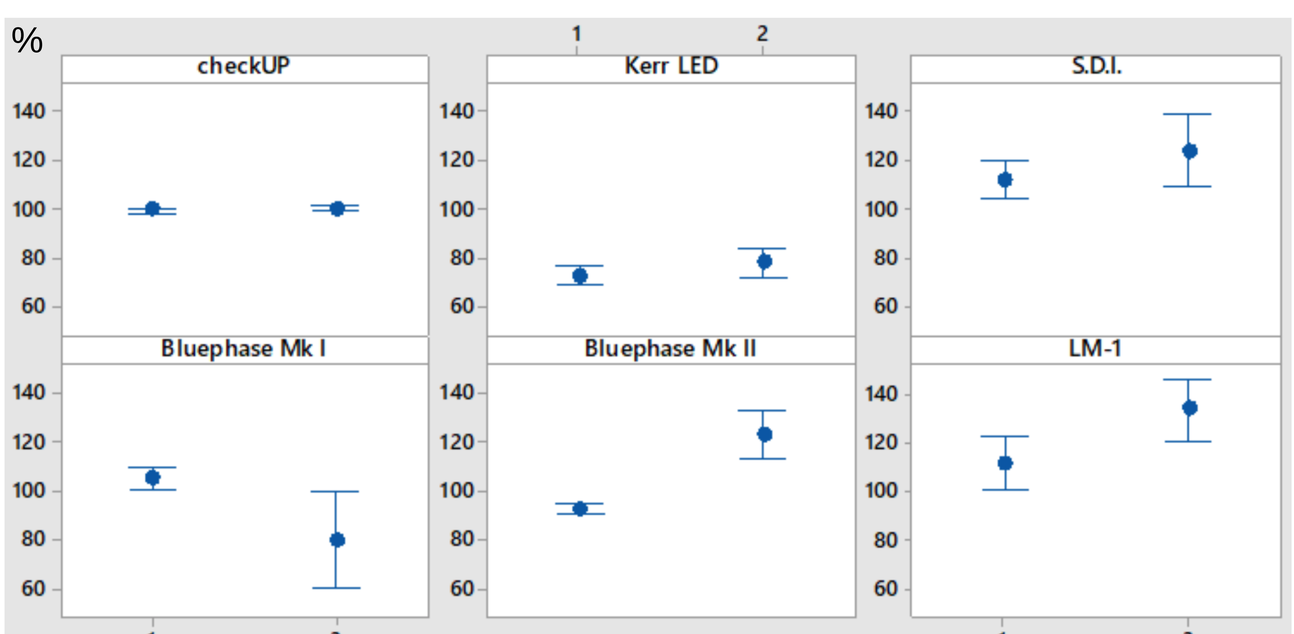

Figure 4^: Percentage (%) difference irradiance values (relative to the integrating sphere (GS) data) of nine Type I and five Type II LED LCU models using five commercial DRs and checkUP. ('1'=Type I; '2'=Type II)

Conclusions:

- Substantial discrepancies may occur between true and estimated radiometric data using current commercial DRs, which may affect LCU users' ability to judge sufficient light exposure critical for successful curing.
- Manufacturers' accuracy claims for dental radiometers should specify compatible LCUs and testing parameters.
- There is a need for more accurate DRs that could be realized with the novel light measurement device checkUP which relies on machine learning to calibrate a nonlinear spectral response sensor and light interaction effects between the light and meter.