Clinical Tooth Whitening Measured by Digital Imaging and Commercial Spectrophotometers

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P. Bellamy*[1], G. Puri[1], A. Noronha[1], A. Mussett[1], M. Somogyl-Mann[2], R. Gerlach[2]

[1]P&G, Rusham Park, Egham, UK, [2]P&G, Mason, OH, USA

ABSTRACT

Objectives A randomized controlled tooth whitening clinical trial was conducted to evaluate treatment differentiation and measurement variability of two commercial spectrophotometers relative to standard digital images.

Methods: Balancing for age and colour, 66 adults were randomly assigned equally to one of three groups: a positive control carbamide peroxide tray-based system QD for 2 hours (Opalescence® 10%), a paint-on peroxide gel *BID* (Signal Xtra White), or an untreated negative control. Subjects received an anticavity dentifrice and brush, and treatment was unsupervised over a 14 days. CIELAB tooth colour was measured on the maxillary anterior tooth surfaces using a standard digital imaging method. In addition, two commercially available contact spectrophotometers, VITA EasyShade® and Shofu® ShadeEye-NCC® measured tooth colour from gingival, middle, and incisal regions.

Results: Mean (SD) age was 31.0 (10.2) years. Both commercial spectrophotometers had statistical outliers that were removed prior to data analysis. Using digital imaging, adjusted mean (SE) Δb^* (yellowness) were -1.7 (0.15), -0.5 (0.10), and -0.2 (0.06) for the positive control, intermediate paint-on gel, and untreated groups, respectively. Results were similar for ΔL^*. All 3 methods showed significant ($p < 0.05$) between-group differences in Δb^* and ΔL^* for the positive and negative controls. The coefficient of variation was lowest with imaging and highest with VITA. Ratios of variance to squared treatment difference between the paint-on and untreated groups ranged from 1.46 with imaging to 1.99 with VITA for Δb^*, and 3.27 with imaging to 31.44 with VITA for ΔL^*.

Conclusions: In a randomized controlled trial, digital imaging and two commercial spectrophotometers differentiated positive and negative whitening controls. There were appreciable sample size implications associated with use of the commercial spectrophotometers to differentiate intermediate and untreated controls.

INTRODUCTION

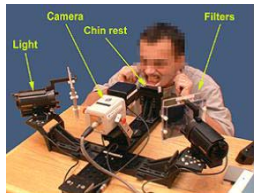
Application of digital imaging has been extensively reported in the literature for the measurement of tooth colour Other systems are available for measuring tooth colour. Bellamy et al[1] reported differences in actual measured CIELAB values as determined by different instruments, as well as disparity in variability of measurements.

Shofu ShadeEye®

Vita EasyShade®

PURPOSE

This research was designed to establish the ability of two commercial spectrophotometers to measure clinically relevant changes in tooth colour provided by tooth whitening systems, which have been previously reported using digital imaging.



Digital Image Analysis System

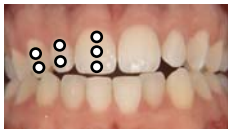
MATERIALS AND METHODS

Design:

- 66 adults randomised to 3 balanced groups based on tooth colour and gender.
- Subjects used treatment for 2 weeks, as per manufacturer's instructions with tooth colour evaluations at baseline and day 15 on all instruments.

Tooth region measured:

Digital imaging – Single image from which 6 maxillary teeth (canine to canine) were evaluated.



Shofu and Vita - 7 measurements across right central incisor (3 readings), lateral incisor (2) and canine (2). Three repeats of each point. Total of 21 readings across 3 teeth. Reported results are average of all 21 readings.

Treatments

A. **Opalescence PF10%** carbamide peroxide custom-fit tray system, worn for 2 hours per day + standardized tooth brushing (same as product C).

B. **Signal Xtra White** 5.9% hydrogen peroxide paint-on system, worn for 2 min twice a day + standardized tooth brushing (same as product C).

C. **No Treatment** Blend-a-Med Cavity Protection Mineral Action dentifrice and Oral B40 soft bristle toothbrush.

CONCLUSION

- Commercial spectrophotometers provide comparable ranking and statistical separation to digital imaging when used to evaluate known differences in product performance.
- Digital imaging provides the lowest variability of the instruments on test, therefore providing the most sensitivity to tooth colour changes.

RESULTS

CIELAB data

- Each instrument provided different L*a*b* values. This would be expected given the varying light source and sensor configuration employed by each instrument.
- Measured treatment difference on the b* axis (Δb^*) is larger using the Vita and Shofu instruments than using digital imaging. Direct comparison of delta L*a*b* from different instruments is not a reliable indicator of relative product performance.
- Variability of DIA data was lowest. The Vita had the highest variability.

		Mean baseline CIELAB (Std Deviation)			Change CIELAB (Modeled Variance)		
Color/Treatment	N	DI	Shofu	Vita	DI	Shofu	Vita
b*							
Opalescence 10%	23	17.7 (1.2)	12.1 (1.4)	21.7 (2.2)	-1.8 (0.5)[a]	-3.4 (1.6)[a]	-3.6 (2.9)[a]
Signal XW	22	17.4 (1.2)	12.0 (2.0)	21.7 (3.2)	-0.5 (0.2)[a]	-0.9 (0.7)[b]	-0.7 (1.6)[b]
No Treatment	21	17.8 (1.2)	11.9 (2.6)	21.7 (3.2)	-0.2 (0.1)[a]	-0.4 (0.2)[c]	-0.0 (0.7)[c]
L*							
Opalescence 10%	23	74.1 (1.6)	70.9 (2.58)	78.9 (3.1)	2.2 (0.7)[a]	2.7 (1.2)[a]	2.7 (1.5)[a]
Signal XW	22	73.9 (2.4)	71.0 (2.3)	78.6 (3.0)	0.4 (0.1)[a]	0.5 (0.3)[b]	0.3 (1.3)[b]
No Treatment	21	74.1 (2.0)	70.8 (2.6)	78.2 (3.4)	0.2 (0.1)[a]	0.3 (0.1)[c]	0.1 (0.5)[c]

[a,b,c] Treatments marked with different letter codes are statistically significantly different from each other in a two-sided testing at a 5% level of significance.

Sample size results

The ratio of variance to squared treatment difference provides a relative estimate of the base size needed to demonstrate significant treatment difference. For example (from the table below), to be confident of showing a treatment difference for Δb^*, using the Shofu instrument, 1.12 times as many subject would be required compared to digital imaging. For Vita it would be 1.37 times.

Sample Size Implications (N is proportional to $\sigma^2/Diff^2$)						
Comparison	Δb^*			ΔL^*		
Estimates[a]	DI	Shofu	Vita	DI	Shofu	Vita
σ^2	0.14	0.44	1.15	0.11	0.18	0.91
$Diff^2$	0.10	0.27	0.58	0.03	0.03	0.03
$\sigma^2/Diff^2$	1.46	1.63	1.99	3.27	5.52	31.44
$N_{One\ Param.Color\ Imp.}$	N_b	$1.12N_b$	$1.37N_b$	N_L	$1.69*N_L$	$9.61*N_L$
$N_{Two\ Param.Color\ Imp.}$[b]	$0.45*N_L$	$0.50*N_L$	$0.61*N_L$	N_L	$1.69*N_L$	$9.61*N_L$

[a] The variance (σ) estimate is a pooled estimate of the Signal XW and No Treatment variance estimates. Diff represents the difference between Signal XW and No Treatment.

[b] The sample size for the two parameter color improvement is the maximum of the individual one parameter color improvement sample sizes.

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