"Shade selection: spectrophotometer vs digital camera – a comparative in-vitro study"

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Abstract

Shade determination may be precisely performed with spectrophotometers, however this technique is time consuming and requires special devices. The aim of this study was to ascertain if digitally acquired images with an SLR camera can be used as an alternative to the VITA easyshade spectrophotometer for obtaining the shade of the teeth. Twenty extracted anterior tooth samples were analysed to determine the L*, a*, b* values with a spectrophotometer. The same samples were imaged with a digital camera, and same colour parameters were determined on the digital images with a software. Statistical analysis was performed using pearson coefficient of correlation. It was observed that the L* and b* values obtained by both the methods were highly significant ($r \geq 0.7$, $p \leq 0.05$) with $r = 0.798$ ($p=0$), $r = 0.858$ ($p=0$) whereas 'a' value was not significant with $r=0.246$ ($p=0.377$). It can be concluded that an SLR camera with Adobe photoshop CS5.1 as an adjunct can be used as an alternative to spectrophotometer in obtaining 'l' and 'b' values accurately.

Keywords: Digital analysis, Spectrophotometric analysis, Colour analysis, Cielab

Introduction

An aesthetic restoration is aimed at achieving biological, morphologic and optical acceptance replicating the natural teeth[(1,2)]. Patient satisfaction of an aesthetic restoration is associated primarily with the outline form, translucency and the shade of the artificial teeth[(3,4)]. Meticulous preparation and precise laboratory techniques help to achieve the desired form of the definitive restoration. The colour matching of the restoration however still remains a dilemma for the dentist[(2)].

The dentist may find it challenging to perform shade matching of a restoration using shade matching tools like the shade guides provided by the restorative materials manufacturers[(2)]. Various components of the shade matching process contribute to the difficulty of achieving an accurate shade match between a restoration and the surrounding dentition. Some of these factors can originate from the subjective nature of the human colour observation[(5,6)].

Additionally factors like fatigue, ageing and emotional status of the clinician along with the lighting conditions and metamerism add to the complexity of the shade matching task[(3,7)]. Traditional method of shade selection is by visual comparison of the shade guides to the adjacent tooth[(2,8)]. However, some important shortcomings of shade guides have been reported that include the inability of the clinician to exactly match the shade of the final aesthetic restoration to those of the natural teeth[(2,4,8,9)].

The standard equipment used to measure the reflectance properties of an object is a spectrophotometer. A dental spectrophotometer has been developed in order to eliminate the uncontrolled variables during the shade matching process[(7)]. An attempt to eliminate the subjectivity of visual colour analysis has led to the introduction of the digital shade analysis systems that attempt to eliminate the subjectivity of visual colour analysis, reducing the chances of miscommunication of colour. Hence, providing precise and uniform fabrication of aesthetic restorations by the dental laboratory technicians[(4,10,11,12)].

Though a dental spectrophotometer is reliable in selecting the shade, it is not easily available to all the clinicians. Digital cameras are a common gadget used in almost every clinic, however not many studies exist in the literature to compare the reliability of a digital camera versus spectrophotometer in selecting the shade of teeth. This study was undertaken to determine the ability of a digital SLR camera as a colorimetric measuring device to determine the shade of the teeth in adjunct with a graphic software.

Aims and Objectives

1. To obtain the colour measurements of extracted natural teeth in CIE l*a*b units using a dental spectrophotometer (VITA easyshade compact).
2. To obtain the colour measurements of extracted natural teeth in CIE l*a*b units using a digital camera and adobe photoshop CS5.1.

Materials and Methodology

Since 1931, CIELAB units, have been used for colour quantification when analysed mathematically to compare the colour parameters of different objects [19]. In this system, the colour space consists of three coordinates L*, a* and b* as depicted in Fig. 1. The L* refers to the lightness coordinate, and its value ranges from 0 for perfect black to 100 for perfect white. The a* and b* are the chromaticity coordinates in the red–green axis and yellow–blue axis, respectively. Positive a* values reflect the red colour range and negative values indicate green colour range. Similarly, positive b* values indicate yellow colour range while negative values indicate the blue colour range[13].

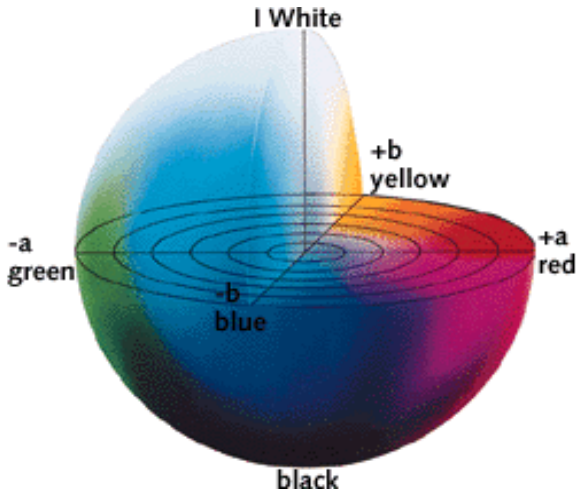

Fig. 1: Displays the cielab coordinate spectrum

In the present study, twenty extracted anterior teeth specimens T1-T20, previously stored in 10% formalin[20], were tested for colour analysis by the use of a dental spectrophotometer (VITA easyshade compact) with D65 illumination to obtain CIE l*a*b values in the middle third of the coronal portion of the teeth specimens as depicted in Fig. 2. Before each measurement session, the spectrophotometer was calibrated according to the manufacturer's recommendations.

Fig. 2: Vita easy shade compact dental spectrophotometer

The same tooth specimens T1-T20 were again tested for colour analysis with the use of a digital SLR camera (Nikon D90 SLR) with a macro lens (Sigma 105mm). The camera was placed on a tripod (Fig. 3) at a distance of 25cm (Fig. 4) from the teeth samples with an 18% reflectance grey card as a contrast and digital images were obtained as shown in Fig. 5.[19] The camera was oriented perpendicular to the tooth samples to obtain the digital images. The images were taken at 11:00 am, under northern daylight, on a clear day[14,16]. The image was resolved on a 24-bit resolution screen, and was analyzed using a graphic software Adobe Photoshop CS5.1 (Fig. 4). Fixed circular areas, 74 pixels in diameter, in the middle third portion of each tooth sample were selected for analysis. The L*, a*, b* values of these areas were measured and the mean values were recorded.

Fig. 3: Digital SLR camera placed on the tripod to obtain image of the tooth sample placed on the 18% reflectance grey card

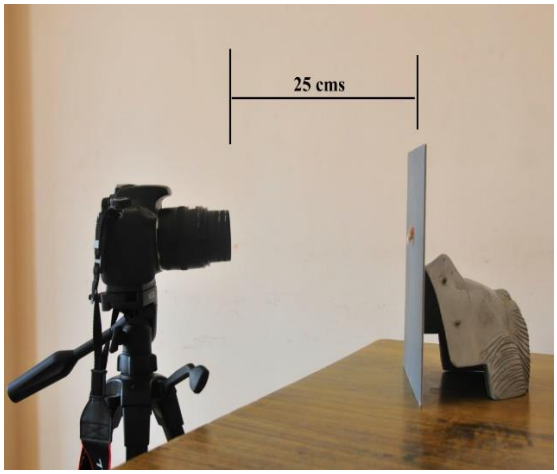

Fig. 4: 25cm distance standardised between the camera and the tooth sample

Fig. 5: Tooth sample t1 placed on 18% reflectance grey card

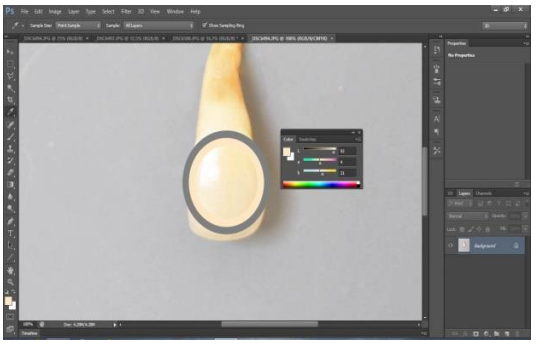

Fig. 6: Adobe Photoshop software to obtain CIE lab values of the tooth samples imaged by the digital camera

The CIE l*a*b values obtained using VITA easyshade compact dental spectrophotometer and digitally acquired images using Adobe Photoshop CS5.1 were then compared and the statistical analysis of the data was performed by application of pearson's coefficient of correlation.

Results

The colour measurements of the tooth samples examined by two methods is presented in Table 1. The mean 'l', 'a', 'b' values obtained using the VITA easy shade compact dental spectrophotometer were 50.69, -0.16, 7.08 respectively. While the mean 'l', 'a', 'b' values obtained using Nikon D90 SLR and Adobe Photoshop CS5.1 were 49.00, 0.40, 6.53 respectively. The mean deviation of 'l', 'a', 'b' using VITA easy shade compact dental spectrophotometer were 1.70, 0.49, 2.86 respectively and mean deviation of 'l', 'a', 'b' using Nikon D90 SLR and Adobe Photoshop CS5.1 were 2.51, 0.63, 2.56 respectively. The data was subjected to statistical analysis using Pearson coefficient of correlation. Statistically the 'l' and 'b' values were highly significant ($r \geq 0.7$, $p \leq 0.05$) with $r = 0.798$ ($p=0$), $r = 0.858$ ($p=0$) whereas 'a' value was not significant with $r=0.246$ ($p=0.377$) as shown in graphs 1, 2 and 3.

Table 1: CIE Lab values of the tooth samples

	Count	Mean	Deviation	Pearson Coefficient
L Value – Spectrophotometer	20	50.69	1.70	r = 0.798
L Value – Digital Camera	20	49.00	2.51	p = 0.000
a Value – Spectrophotometer	20	-0.15	0.49	r = 0.246
a Value – Digital Camera	20	0.40	0.63	p = 0.377
b Value – Spectrophotometer	20	7.08	2.86	r = 0.858
b Value – Digital Camera	20	6.53	2.56	p = 0.000

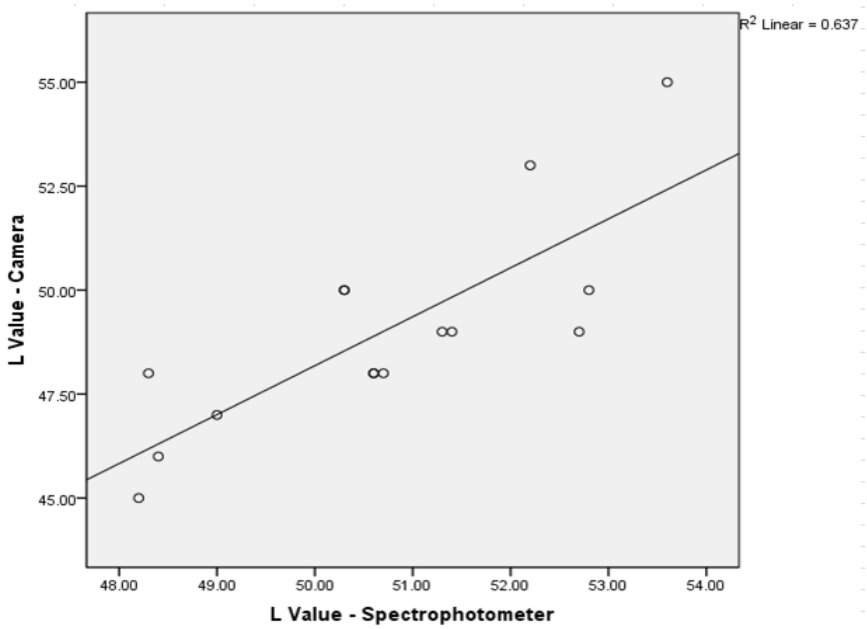

Fig. 1: a Value correlation

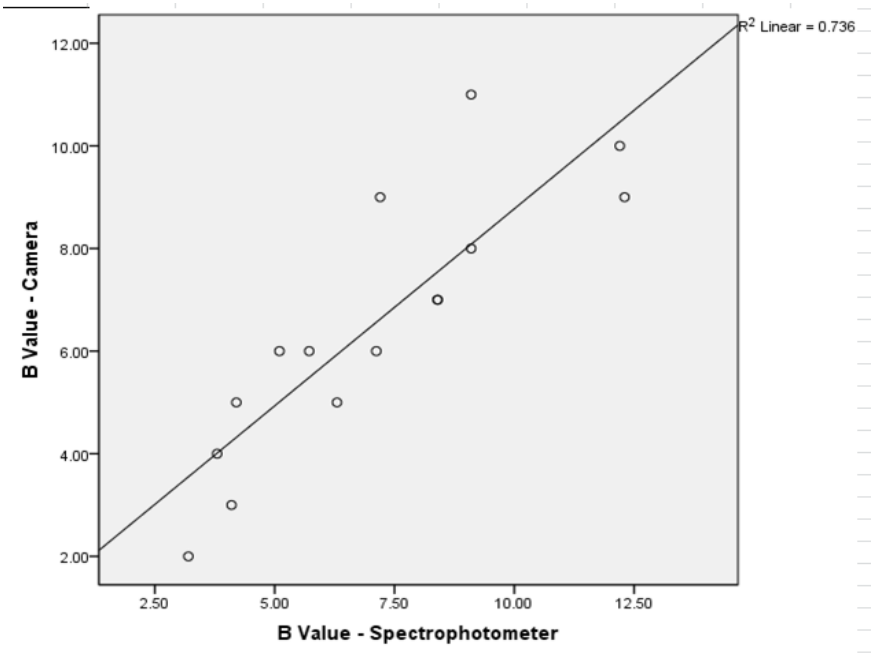

Fig. 2: b Value correlation

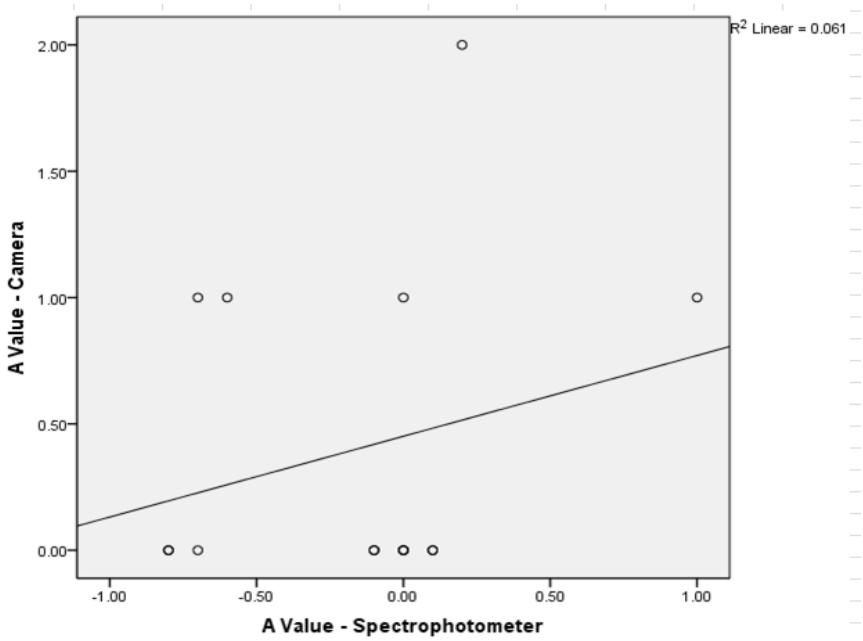

Fig. 3: a Value correlation

Discussion

One of the primary goals of aesthetic dentistry is to provide functional and natural appearing dental restorations for the patients. The important steps in providing this service is by establishing the most natural appearing teeth. To achieve this, dental spectrophotometers are specially designed to obtain the shade of a tooth or a restoration and to obtain CIE l*a*b values.

Since digital camera is a common gadget in every dental clinic, this study was undertaken to ascertain if digitally acquired images with an SLR camera can be used as an alternative to the VITA easyshade spectrophotometer for obtaining the shade of the teeth in a cost effective manner.

The digital images of the tooth specimens obtained using Nikon D90 SLR camera with sigma 105 mm macro lens were standardized by keeping the distance between the teeth samples and the camera set on a tripod at a distance of 25 cms with 18% reflectance grey card background obtained under natural daylight[19]. A grey card background is recommended as this would eliminate the effect of scattering light on the images, which may interfere with the colour measurements[10].

The 'l' and 'b' values of all the twenty samples obtained using the digital images processed with Adobe photoshop CS5.1 were similar to those obtained using VITA easyshade compact and were statistically significant. However, the 'a' value obtained using the digital images processed with Adobe photoshop CS5.1 were not similar and were not statistically significant to those obtained using VITA easyshade compact.

The limitations of the study included a small sample size and it was an in-vitro study. No gold standard was used in the tests, as the purpose was not to determine which method led to the most accurate results; rather, investigation of the presence of linear relationship between the performances of spectrophotometer and digital analysis was of interest.

The present study demonstrated that application of the digital analysis along with a software program for colour determination of tooth specimens yielded results in l* and b* measurements that correlated with those obtained with the spectrophotometer. Therefore, it may be speculated that this method appears to deserve further evaluations to be considered as another way of establishing colour in dentistry.

Conclusion

It can be concluded that colour measurements obtained with digital analysis method were in accordance with those of spectrophotometric evaluations, with respect to the l* and b* values obtained using digital images processed with Adobe photoshop CS5.1 and were statistically significant and reliable. While the 'a' value obtained was not statistically significant and were not reliable. From the results of this study it can be concluded that an SLR camera with Adobe photoshop CS5.1 as an adjunct can be used as an alternative to spectrophotometer in obtaining 'l' and 'b' values accurately.

This finding may require further assessment of digital method's capability in determining the colour changes in aesthetic dentistry, and would provide a more practical and consistent method to determine the colour in vivo in dental clinics and to transmit this information to the dental laboratories.

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