# Comparative Evaluation of Shade Matching of Vital Maxillary Central Incisor by Different Observers, Shade Guides and Instrument

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## Abstract

**Objectives:** This study tested the hypothesis that the agreement between observer visual dental shade matches and instrumental shade identification is higher using the Vita 3DMaster ® (3D) shade guide than the Vita classical (VC) shade guide.

**Methods:** 100 subjects were matched with visual and instrument; spectrocolorimeter for shade selection and result were tabulated.

**Results:** The result obtained showed that Spectrocolorimeter has more value of lightness, redness or greenness, blueness or yellowness (L*,a*,b*) when compared with Vitapan classical and Vitapan 3D Master. Vitapan 3D Master has more lightness, redness or greenness (L*, a) is more than Vitan Classical expect blueness or yellowness of colour.

**Significance:** A significantly higher visual–instrumental shade agreement was demonstrated by the clinically experienced dentists (DD), regardless of shade guides and lighting conditions. Incandescent light bulb emits relatively higher concentrations of yellow light waves than of blue and blue-green, whereas fluorescent ceiling fix-lures give off relatively high concentrations of blue Waves

## Introduction

The study of color is an integral part of esthetic dentistry. Without light, color does not exist. Scientifically, light is described as visible electromagnetic energy whose wavelength is measured in nanometers (nm) or billionths of a meter. The eye is sensitive only to the visible part of the electromagnetic spectrum, a narrow band with wavelengths of 380 to 750 nm. At the shorter wavelengths lie ultraviolet; x, and gamma rays; at the longer wavelengths are infrared radiation, microwaves, and television and radio transmissions. The most common light sources in dental offices are incandescent and fluorescent, neither of which are pure white light.

The most popular method for describing color is the Munsell Color order system. The three attributes of color in this system are called Hue, Value, and Chroma.[4,5,6] Hue is defined as the particular variety of a color, shade, or tint. The Hue of an object can be red, green, yellow, and so on, and is determined by the wavelength of the reflected and/or transmitted light observed. The place of that wavelength (or wavelengths) in the visible range of the spectrum determines the Hue of the color. The shorter the wavelength, the closer the Hue will be to the violet

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portion of the spectrum; the longer the wavelength, the closer it will be to the red portion. Chroma is defined as the intensity of a Hue. Value is defined as the relative lightness or darkness of a color or the brightness of an object. The brightness of any object is a direct consequence of the amount of light energy the object reflects or transmits [2,3]

CIELAB Color System was determined by the Commission Internationale de 1'Eclairage in 1978. In both the Munsell and the CIELAB color order systems, the location in the color space of a particular shade is defined by three coordinates: Value, Hue, and Chroma for Munsell; L*, a*, and b* for CIELAB. Value and L* are proportional to each other and represent the lightness, brightness, or black/white character of the color. The L* value is a measure of the lightness of an object. The a* value is a measure of redness (positive a*) or greenness (negative a*).The b* value is a measure of yellowness (positive b*) or blueness (negative b*). The advantage of the CIE Lab system is that color differences can be expressed in units that can be related to visual perception and clinical significance.[3,7-13] Translucency is the gradient between transparent and opaque. Fluorescence is the absorption of short wavelength light with the spontaneous emission of longer wavelength light. Opalescence makes a material appear one color with reflected light and another color with transmitted light [2,15,16] In prosthetic applications, color selection for artificial teeth is based mainly on visual comparison of the remaining teeth with the aid of commercially available shade guides as the color standard. Two methods commonly used to analyze the color of natural teeth and shade guides are (1) Visual comparison and (2) Instrumental measurement[20]

**Materials And Methods**

**Materials Used**

1. Cotton (fig. 1)

2. Toothpaste

3. Brush

4. Gc polishing paste (fig.2)



Fig.1



Fig.2

**Instruments and Equipments**

1. Diagnostic instrument – Mouth mirror, (fig.3)

–Straight probe,

–Tweezers

2. Kidney tray

3. Ultrasonic scalers (fig.4)

4. Polishing cups

5. Contra angle micro motor (fig.5)

6. Shade guide (Vitapan classical) (fig. 6)

7. Shade guide (Vita Toothguide 3D-Master shade guide) (fig.7)

8. Spectrocolorimeter (X-Rite RM200QC) (fig.8)

Diagnostic instruments



Fig.3

Ultrasonic scalers



Fig.4

Scaler tip, Contra angle micro motor and Polishing cup with Dipendish



Fig.5

Shade guide (Vitapan Classical)



Fig.6

Shade guide (Vita Toothguide 3D-Master shade guide)



Fig.7

Spectrocolorimeter (X-Rite RM200QC)



Fig.8

**Methodology**

**Method of Collection of Data**

100 randomly selected male and female subjects between age group 18 to 25 years reporting to the Department of Oral Medicine and Radiology was taken for this study.

This study was conducted in the Department of Prosthodontics, Crown and Bridge, Bangalore Institute of Dental Science & Research Centre, Bangalore.

**Inclusion Criteria**

Subjects having following conditions was included in this study:

1) Age group within 18 to 25 years.

2) Subjects having full complement of upper and lower anterior teeth.

3) No caries or restorations in upper and lower anterior teeth.

4) Well aligned without crowding and spacing of upper and lower anterior teeth.

5) Patients who have consented to be the part of this study.zsw

**Exclusion Criteria**

Subjects having following conditions was excluded from this study:

1) Fluorosis

2) Attrition

3) Abrasion

4) Erosion

5) Amelogenesis Imperfecta

6) Dentinogenesis Imperfecta

7) Hyperplastic teeth

8) Gingival and periodontal diseases

9) Tetracycline stains

10) Patients who are unwilling to give consent.

A Proforma was prepared in which patients consent and signatures was taken prior to their participation in this study.

**Procedure**

Right central incisor of subjects were selected as per inclusion and exclusion criteria and their color were evaluated by three selected observers using 2 shade guides- Vitapan classical and Vita Toothguide 3D-Master shade guide. The reading of the observers were tabulated. The values of the reading were given in L*(lightness of color), a*(redness or greenness of color), b*(yellowness or blueness) which was taken from the table given in Contemporary Fixed Prosthodontics (1st south Asian Edition), (CILAB Values).

The surface of tooth were wiped with cotton for removal of saliva and moisture before

color measurement. Oral prophylaxis with ultrasonic scaler and polishing with GC polishing paste was done if needed before color measurement. (fig.9)



FIG-1 ORAL PROPHYLAXIS

Fig.9

For visual evaluation, three observers were taken to ophthalmologist to do eye testing for normal color vision before they are allowed to perform shade matching. (fig.10)



FIG-6 SHADE MATCHING BY 3 OBSERVERS, VISUALLY

Fig.10

Shade matching was done by the following conditions:

1. Shade matching was done under ideal lightening condition and in an appropriate shade-matching environment with pastel color wall.

2. Anything on the patient that influences the shade matching, including brightly colored clothing, was draped, and lipstick was removed.

3. The teeth to be matched was cleaned. If necessary, stains was removed by oral prophylaxis.

4. Shade matching was made during morning time between 9 am to 11 am.

5. The patient was viewed at eye level so that the most color-sensitive part of the retina was used.

6. A viewing working distance of approximately 10 inches (25cm) was adopted.

7. Shade matching was made quickly (less than 5 seconds), with the shade guide placed directly next to the tooth being matched. This ensures that the background of the tooth and the shade sample are the same, which is essential for accurate matching.

8. The observers was allowed to rest their eyes every 10 seconds by looking at a blue or gray background to resensitize color vision.

9. All the three observers were present at the time of shade matching, and each observer selected the shade by placing the shade guides (VC and 3DM) individually against the tooth and the value was noted and then were tabulated in L*,a* and b* values. Spectrocolorimeter (X- Rite RM200QC) was used for instrument color evaluation.

The device was placed on the selected tooth and the readings will be generated on the device in L*, a*and b* values. The reading of SC was tabulated. (fig.11)



Fig.11

This study comprises of 6 groups which was further divided into 3 study group and 3 control group.

The three study group were:

1. Observer 1

2. Observer 2

3. Observer 3

The three control group were:

1. Vitapan classical (Group 1)

2. Vitapan 3D-Master (Group 2)

3. Spectrocolorimeter (Group 3)

**Result**

The present study was aimed to compare and evaluate the shade matching of vital right maxillary central incisor by using three different observers, two shade guide (VC and 3DM) and an instrument (SC) in 100 subjects.

The three observers in study group were Obs-1, Obs-2 and Obs-3 and in controlled groups: VC (Group1), 3DM (Group2) and SC (Group3). The values of the study group and controlled group were tabulated in according to CIELAB values.

Table -5 Intraclass correlation coefficients for L* a* b* values in different shade guides measuring the interrater reliability.

| Shade Guide | Variable | ICC | 95% Conf. Interval | | P-Value |
|---|---|---|---|---|---|
| | | | Lower | Upper | |
| VITA Pan Classical | L* | 0.89 | 0.84 | 0.92 | <0.001* |
| | a* | 0.88 | 0.84 | 0.92 | <0.001* |
| | b* | 0.90 | 0.85 | 0.93 | <0.001* |
| VITA 3D Master | L* | 0.95 | 0.92 | 0.96 | <0.001* |
| | a* | 0.95 | 0.94 | 0.97 | <0.001* |
| | b* | 0.94 | 0.92 | 0.96 | <0.001* |

\* - Statistically Significant

ICC Interpretation

<0.50 Poor reliability

0.51 - 0.75 Moderate reliability

0.76 - 0.90 Good reliability

**Table -6 Comparison of mean L, a & b values obtained by Vita Pan classical and Vita 3D Master shade guide between 03 observers using one-way ANOVA**

| Comparison of mean L, a & b values obtained by Vita Pan classical shade guide between 03 observers using one-way ANOVA | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Variables | Observers | N | Mean | SD | Std. Error | Min | Max | F | P-Value |
| L* | Obs-1 | 100 | 78.02 | 2.99 | 0.30 | 72.7 | 82.4 | | |
| | Obs-2 | 100 | 78.44 | 2.92 | 0.29 | 72.7 | 82.4 | 0.987 | 0.37 |
| | Obs-3 | 100 | 78.56 | 2.67 | 0.27 | 72.7 | 82.4 | | |
| a* | Obs-1 | 100 | -0.48 | 0.90 | 0.09 | -1.9 | 1.0 | | |
| | Obs-2 | 100 | -0.61 | 0.91 | 0.09 | -1.9 | 1.0 | 1.069 | 0.35 |
| | Obs-3 | 100 | -0.66 | 0.86 | 0.09 | -1.9 | 1.0 | | |
| b* | Obs-1 | 100 | 16.61 | 3.31 | 0.33 | 12.6 | 25.0 | | |
| | Obs-2 | 100 | 16.40 | 3.07 | 0.31 | 12.6 | 21.1 | 0.138 | 0.87 |
| | Obs-3 | 100 | 16.41 | 3.09 | 0.31 | 12.6 | 25.0 | | |

| Comparison of mean L, a & b values obtained by Vita 3D Master shade guide between 03 observers using one-way ANOVA | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Variables | Observers | N | Mean | SD | Std. Error | Min | Max | F | P-Value |
| L* | Obs-1 | 100 | 79.25 | 3.62 | 0.36 | 73.1 | 84 | | |
| | Obs-2 | 100 | 79.41 | 3.58 | 0.36 | 73.1 | 84 | 0.047 | 0.95 |
| | Obs-3 | 100 | 79.35 | 3.50 | 0.35 | 73.1 | 84 | | |
| a* | Obs-1 | 100 | 0.60 | 0.96 | 0.10 | -0.2 | 3.5 | | |
| | Obs-2 | 100 | 0.62 | 0.95 | 0.09 | -0.2 | 3.5 | 0.010 | 0.99 |
| | Obs-3 | 100 | 0.60 | 0.94 | 0.09 | -0.2 | 3.5 | | |
| b* | Obs-1 | 100 | 18.93 | 4.23 | 0.42 | 12.5 | 26.2 | | |
| | Obs-2 | 100 | 18.83 | 4.18 | 0.42 | 12.5 | 26.2 | 0.036 | 0.97 |
| | Obs-3 | 100 | 18.99 | 4.24 | 0.42 | 12.5 | 26.2 | | |

**Table-7 Comparison of mean L, a & b values between Vita Pan classic, Vita 3D Master shade guides and Spectrocolorimeter instrument using one-way ANOVA followed by Scheffe's Post hoc Analysis**

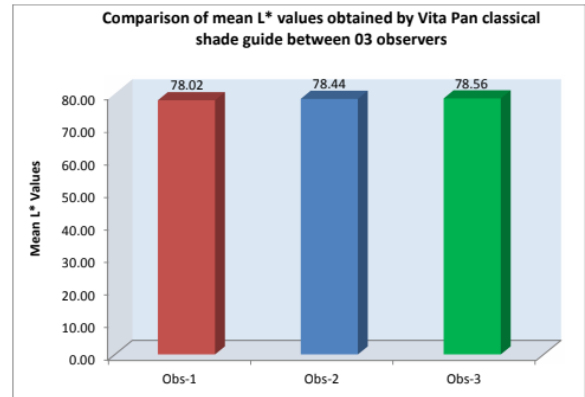| Comparison of mean L, a & b values between Vita Pan classical, Vita 3D Master shade guides and Spectrocolorimeter instrument using one-way ANOVA followed by Scheffe's Post hoc Analysis | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Variables | Method | N | Mean | SD | Std. Error | Min | Max | F | P-Value |
| L* | Group 1 | 100 | 79.20 | 4.02 | 0.40 | 71.4 | 87.5 | | |
| | Group 2 | 100 | 78.34 | 2.58 | 0.26 | 72.7 | 82.4 | 2.557 | 0.08 |
| | Group 3 | 100 | 79.34 | 3.38 | 0.34 | 73.1 | 84.0 | | |
| a* | Group 1 | 100 | 0.56 | 0.96 | 0.10 | -0.5 | 3.7 | | |
| | Group 2 | 100 | -0.59 | 0.80 | 0.08 | -1.9 | 1.0 | 57.086 | <0.001* |
| | Group 3 | 100 | 0.61 | 0.91 | 0.09 | -0.2 | 3.5 | | |
| b* | Group 1 | 100 | 18.74 | 7.71 | 0.77 | 10.4 | 76.0 | | |
| | Group 2 | 100 | 16.47 | 2.87 | 0.29 | 12.6 | 21.4 | 6.664 | 0.001* |
| | Group 3 | 100 | 18.92 | 3.99 | 0.40 | 12.5 | 26.2 | | |

\* - Statistically Significant

Note: Group 1 - Vita PAN Classical shade guide, Group 2 - Vita 3D Master, Group 3
- Spectrocolorimeter

**Table-8 Multiple comparison between 03 groups using Scheffe's post hoc Analysis**

| Multiple comparison between 03 groups using Scheffe's post hoc Analysis | | | | |
|---|---|---|---|---|
| Variable | Group (i) | Group (j) | Mean Diff | P-Value |
| L* | Group 1 | Group 2 | 0.86 | 0.20 |
| | | Group 3 | -0.14 | 0.96 |
| | Group 2 | Group 3 | -1.00 | 0.12 |
| a* | Group 1 | Group 2 | 1.14 | <0.001* |
| | | Group 3 | -0.05 | 0.93 |
| | Group 2 | Group 3 | -1.19 | <0.001* |
| b* | Group 1 | Group 2 | 2.27 | 0.01* |
| | | Group 3 | -0.18 | 0.97 |
| | Group 2 | Group 3 | -2.45 | 0.005* |

\* - Statistically Significant

Note: Group 1 - Vita PAN Classical shade guide, Group 2 - Vita 3D Master, Group 3
- Spectrocolorimeter

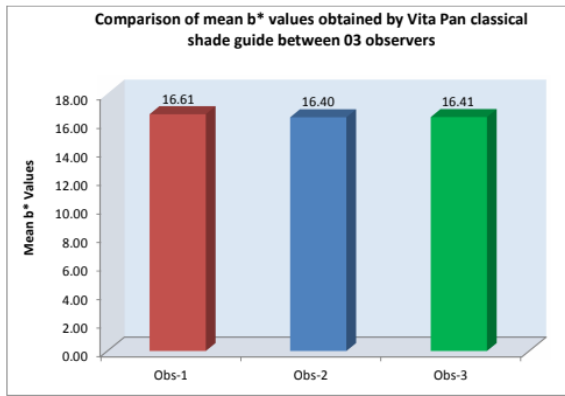**Graph- 1 Comparison of mean L\* values obtained by Vita Pan classical shade guide between 03 observers**
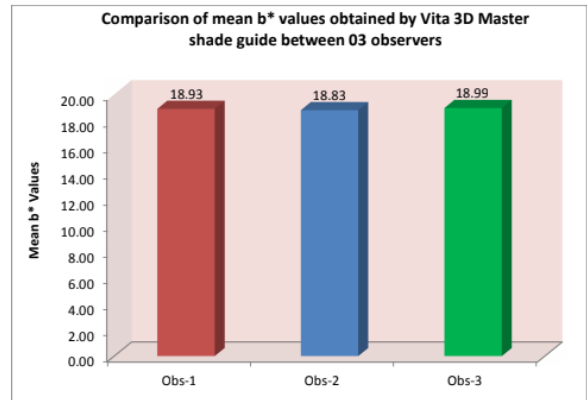


Comparison of mean L* values obtained by Vita Pan classical shade guide between 03 observers

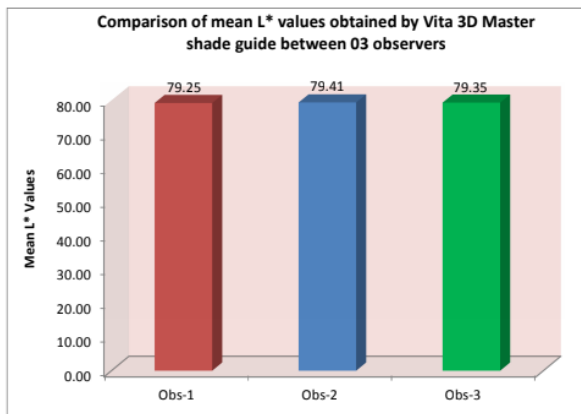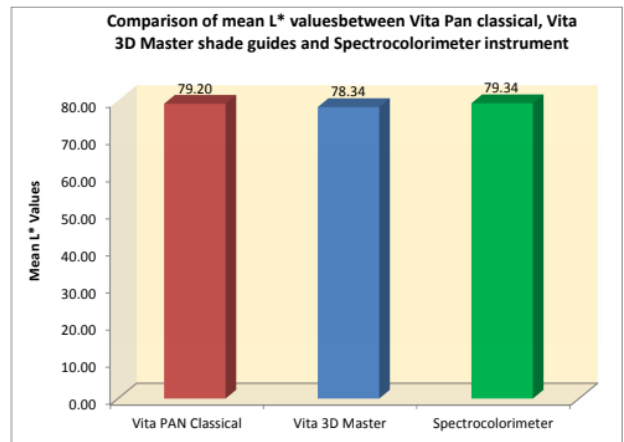**Graph-2 Comparison of mean a\* values obtained by Vita Pan classical shade guide between 03 observers**



Comparison of mean a* values obtained by Vita Pan classical shade guide between 03 observers
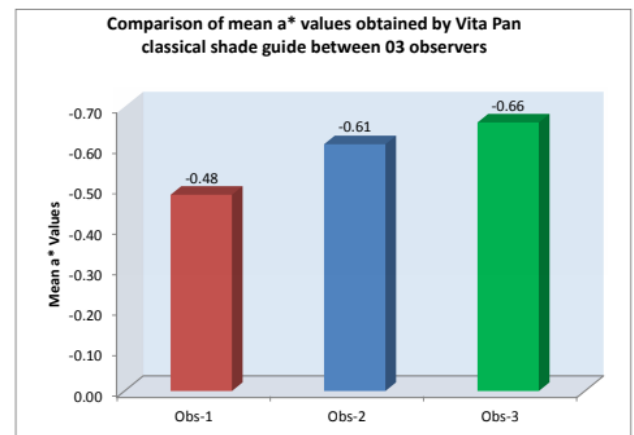
**Graph -3 Comparison of mean b\* values obtained by Vita Pan classical shade guide between 03 observers**



**Graph – 6 Comparison of mean b\* values obtained by Vita 3D Master shade guide between 03 observers**
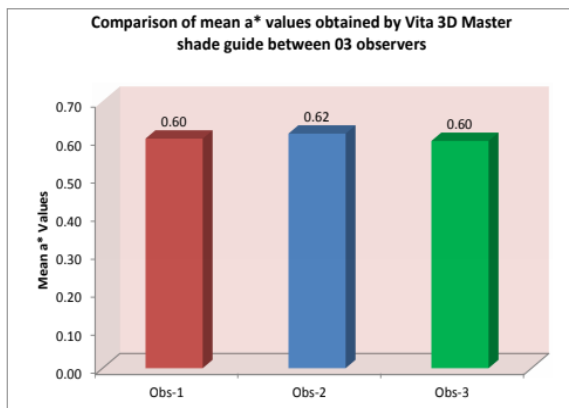


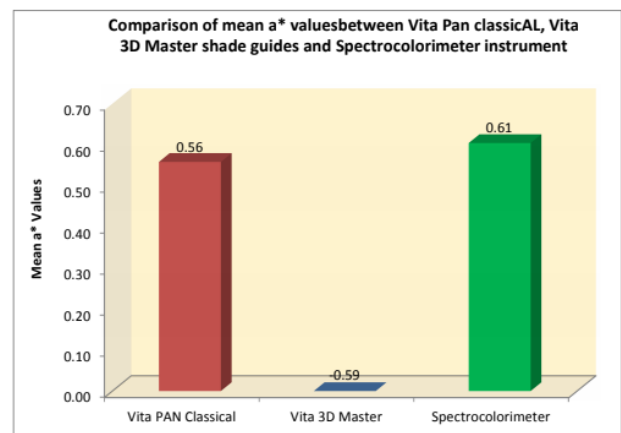**Graph -4 Comparison of mean L\* values obtained by Vita 3D Master shade guide between 03 observers**



**Graph – 7 Comparison of mean L\* values between Vita Pan classical, Vita 3D Master shade guides and Spectrocolorimeter instrument**



**Graph – 5 Comparison of mean a\* values obtained by Vita 3D Master shade guide between 03 observers**



**Graph – 8 Comparison of mean a\* values between Vita Pan classical, Vita 3D Master shade guides and Spectrocolorimeter instrument**

Graph – 9 Comparison of mean b* values between Vita Pan classical, Vita 3D Master shade guides and Spectrocolorimeter instruments



Comparison of mean b* valuesbetween Vita Pan classical, Vita 3D Master shade guides and Spectrocolorimeter instrument
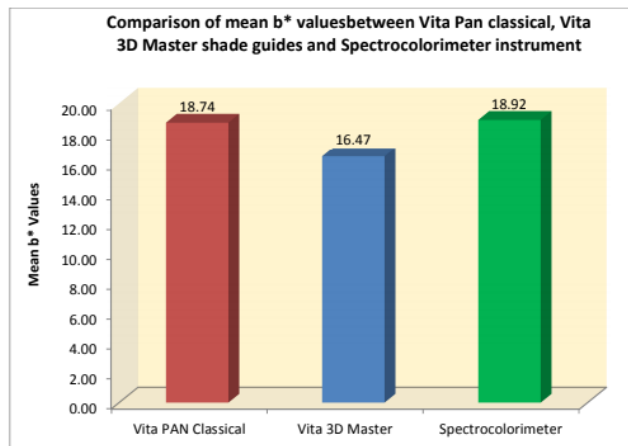
## Discussion

Color is complex and encompasses both subjective and objective phenomena.

Subjective attributes and cannot be objectively measured. Forty years ago, Clark said, "Color, like form, has three dimensions, but they are not in general use. Professional color matchers today have a greater appreciation of the role of the human observer, the differences in light sources, the analysis of surfaces, the effect of the surrounding color—adjacent or background— and the many other aspects of color matching that enter into the final evaluation by the brain.[31, 73,74]

Our perception of color is accepted as subjective and problems in its measurement can be anticipated. In an effort to translate from the physical facts of color, such as measurement of reflectance as a function of wavelength, to the psychologic (i.e., perceptual) facts of color, the science of color measurement (colorimetry) has established an international psychophysical method of color specification which includes a "standard observer" and standardized light sources. This approach has

supplied an operating base for our attempts to measure objectively this subjective phenomenon.[31,33]

The visual shade selection varies, depending on the clinician's color perception and experience, ambient light condition, background of the tooth, and the shade guide used. Instrumental method is objective and appears to be more accurate; however, the quantitative instrumental evaluation is limited to reading one point at a time.

Besides visual assessment with a shade guide, tooth color can be measured with colorimetry, spectrophotometry, and digital cameras. [34,35,76] Among the various methods used to classify tooth color, the Vita shade guide is the most frequently used, which justifies use of this guide in this study. Visual assessment depends on several variables, including the source of illumination, the characteristics of the tooth and variation in observer training and experience. [31]

Tung et al found that the ShadeEye system agreed with itself 82% of the time, whereas clinicians agreed with each other on 73% of the selected shades.[10] Preston and Miller stated many of the errors associated with the use of commercial shade guides and indicated a lack of red shades based on Spectrophotometric measurements of extracted teeth reported by Sproull. When the natural tooth color was evaluated with shade guides, the most frequently chosen shades were of reddish brown hues A3 and A2. The frequent selection of the reddish brown hues is in broad agreement with spectrophotometric work investigating the color of human teeth. [20] Shades in the D range were rarely selected.[10,34,75] Sproull, in the early 1970s, suggested that an ideal shade guide should consist of shade (color) tabs that are well distributed and logically arranged in color space. He

recommended sucha shade guide based on the Munsell Color Order system.[10,34] Lemire and Burk investigated the distribution and frequency of natural tooth color

space in 1974 using a spectrophotometer and concluded that the color space occupied

by natural teeth was larger than that measured by the shade guides.[34]

Preston identified several problems associated with popular shade guides. He described the confounding influence of the gingival tissue during shade assessment, and addressed the material differences between shade tabs and restorative ceramics.

Quality control issues regarding color mismatches of shade tab and porcelain batches from the same manufacturer could be as problematic as mismatches among manufacturers. Preston related that quality control of color in dental manufacturing was generally inconsistent, primarily because it was accomplished visually.[34,75]

Goodkind and Loupe surveyed dental educators and reported that the respondents suggested that a full range of natural tooth colors should be included in the shade guides. Further, Schwabacher and Goodkind, in 1990, reiterated that shade guides did not match well with the color space of human teeth.[34]

Tooth color has been shown to result from the volume scattering of light, i.e. illuminating light follows highly irregular light paths through the tooth before it emerges at the surface of incidence and reaches the eye of the observer. [33]

E. Cal et al compared different methods of shade selection and concluded that color measurements obtained with digital analysis method were in accordance with those of spectrophotometric evaluations, with respect to a* and b* values. This finding may require further assessment of digital method's capability in determining the color changes in aesthetic dentistry, and would provide a more practical and consistent method to determine the color in dental clinics and to transmit this information to dental laboratories. [35,76]

Purpose of this study was to compare and evaluate shade matching of right vital maxillary central incisor by three different observers, shade guides and instrument (spectrocolorimeter).

For L* value , the test results demonstrated that spectrocolorimeter has a highest mean score of 79.34 ± 3.38, followed by VitaPan Classical exhibits a mean score of 79.20 ± 4.02 and VitaPan 3D Master has a least mean score of 78.34 ± 2.58. However, the mean L* values did not present a statistically significant difference [P=0.08] between the 03 methods.

Hence it can be inferred that spectrocolorimeter has increased lightness than Vitapan classical and Vitapan 3DMaster and Vitapan 3D Master has more lightness of color than Vitapan Classical. Among the observers, in Vitapan Classical observer 3 and in Vitapan 3D Master observer 2 has highest lightness of color.

For a* value, the test results demonstrated that spectrocolorimeter has a highest mean score of 0.61 ± 0.91, followed by VitaPan Classical exhibits a mean score of 0.56 ± 0.96 and VitaPan 3D Master has a least mean score of -0.56 ± 0.96. For a* value, the test results demonstrated that spectrocolorimeter has a highest mean score of 0.61 ± 0.91, followed by VitaPan Classical exhibits a mean score of 0.56 ± 0.96 and VitaPan 3D Master has a least mean score of -0.56 ± 0.96. The mean scores had a statistically significant difference between 03 methods [P<0.001]

Multiple comparisons between the groups using Scheffe's post hoc analysis demonstrated that VitaPan 3D Master exhibited a significantly lowest mean a* values compared to VitaPan Classical & Spectrocolorimeter, both at P<0.001. However, the mean score between VitaPan 3D & Spectrocolorimeter Master did not present a statistically significant difference [P=0.96].

Hence, it can be inferred that spectrocolorimeter has more redness or blueness of the color than Vitapan classical and Vitapan 3D Master and Vitapan Classical has more rednees or blueness of color than Vitapan 3D Master. Among the observers, in Vitapan Classical observer 1 and Vitapan 3D Master observer 2 has highest redness or blueness of color.

For b* value, the test results demonstrated that Spectrocolorimeter findings has a highest mean score of 18.92 ± 3.99, followed by VitaPan Clasical exhibits a mean score of 18.74 ± 7.71 and VitaPan 3D Master has a least mean score of 16.47 ± 2.87. The mean scores had a statistically significant difference between 03 methods [P<0.001].

Multiple comparisons between the groups using Scheffe's post hoc analysis demonstrated that VitaPan 3D Master exhibited a significantly lowest mean b* values compared to VitaPan Classical & Spectroclorimeter, at P=0.01 & P=0.005 respectively. However, the mean score between VitaPan Classical & Spectrocolorimeter did not present a statistically significant difference [P=0.97].

Hence it can be inferred that Spectroclorimeter has highest value of yellowness or greenness of the color than Vitapan classical and Vitapan 3DMaster and Vitapan Classical has more yellowness or blueness of color than Vitapan 3D Master. Among the observers, in Vitapan Classical observer 1 and in Vitapan 3D Master observer 3 has highest value of yellowness or blueness of color.

## Conclusion

Within the limitations of the study, the following conclusions were drawn:

1. Spectrocolorimeter has more value of lightness (L*) when compared with

Vitapan classical and Vitapan 3D Master.

2. Vitapan 3D Master has more value of lightness (L*) when compared with

Vitapan Classical.

3. Among observers, in Vitapan Classical observer 3 and in Vitapan 3D Master observer 2 has more lightness (L*) of color.

4. Spectrocolorimeter has more value of redness or greenness (a*) when compared with Vitapan classical and Vitapan 3D Master.

5. Vitapan Classical has more value of redness or greenness (a*) when compared with Vitapan 3DMaster.

6. Among observers, in Vitapan Classical observer 1 and in Vitapan 3D Master observer 2 has more redness or greenness (a*) of color.

7. Spectrocolorimeter has more value of blueness or yellowness (b*) when compared with Vitapan classical and Vitapan 3D Master.

8. Vitapan Classical has more value of blueness or yellowness (b*) when compared with Vitapan 3D Master.

9. Among observers, in Vitapan Classical observer 1 and in Vitapan 3D Master observer 3 has more blueness or yellowness (b*) of color.

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