

Comparison between Visual shade selection and Instrumental Shade Determination using Intra Oral Scanner and Digital Spectrophotometer

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ABSTRACT

Background: Improper shade selection is one of the most common causes behind restorations' remake and patient dissatisfaction. Multiple protocols and devices have been proposed to address the limitations of visual shade selection. **Objective:** To compare the accuracy of dental shade matching gathered visually with both VITA Classical (VC) and VITA 3D-Master (V3D) shade guides with those obtained instrumentally with both 3Shape Trios 3 and VITA Easyshade® Advance 4.0.

Materials and Methods: For visual shade selection (VSS), one- hundred participants from King AbdulAziz University, Faculty of Dentistry participated in the study and asked to select the shade of six masked shade tabs from both VC [A1, A2, B1] and V3D [1M1, 2M3, 3R1.]. Later, Instrumental shade determination (ISD) was completed by one experienced participant for six cycles using: VEasy and Trios 3. **Results:** Significant difference was found between VSS and ISD. The results suggested that although participants significantly preferred VC over V3D in terms of VSS, this did not improve the shade selection performance. Besides, in ISD, no significant difference was reported between VEasy and Trios 3. There was no statistical significance difference between neither Trios 3 when combined with VC and V3D nor between VEasy when combined with VC and V3D. VEasy showed the best shade selection performance when combined with V3D, although the difference was non-significant. **Conclusion:** The result of the present study supports the promising use of the intra oral scanner 3Shape Trios 3 and dental spectrophotometer VITA Easyshade® Advance 4.0. Combination with a visual selection method may result in more accurate and reliable results.

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How to cite this article: Maksoud HBA, Sajini SI, Eid BM, Alhssaini SN, Alanazi YH (2023) Comparison between Visual shade selection and Instrumental Shade Determination using Intra Oral Scanner and Digital Spectrophotometer. Journal of Complementary Medicine Research, Vol. 14, No. 2, 2023 (pp. 85-89)

INTRODUCTION

Esthetic dentistry nowadays shows several advancements with the latest technologies to achieve better esthetic results. Dental restorations are considered the key to achieve an attractive smile for every single person (Moodley et al., 2015). This perfect smile is determined by several elements which have a tremendous effect on the overall smile appearance (Öngül et al., 2012). These elements include teeth shape, position, color, alignment, as well as teeth size.

Dentists' lack of knowledge and comprehension about different color components and shade selection protocols resulted in improper shade selection, which is considered one of the most common causes behind restoration' remake and patient dissatisfaction (Miyajiwala et al., 2017). It was also reported that an aesthetically successful restoration depends on proper matching with adjacent teeth, color, surface texture, and translucency (S. I. Sajini et al., 2022).

Dental shade matching can be performed either visually or instrumentally. Visual shade selection (VSS) is the most frequently applied technique although being subjective in addition to facing a lot of variables that lead to inconsistencies in shade selection. These may include dyschromatopsia, operator's age and experience, eye fatigue, and ambient conditions such as background color and lighting (Van der Burgt et al., 1990). Additionally, VSS faces another limitation which is the availability of shade guide systems (Paul S, Peter A, Pietrobon N, 2002). Besides, all available shade guide systems are not represented in a full color spectrum as the natural teeth. They are usually fabricated with different materials other than the restorative materials used which results in significant errors.

KEYWORDS:

Visual,
Digital,
Dental,
Shade,
intra oral scanner,
spectrophotometer,
3Shape Trios 3,
VITA Easyshade®
Advance 4.0.

ARTICLE HISTORY:

Received : Dec 15, 2022
Accepted : Jan 16, 2023
Published: Feb 17, 2023

DOI:

10.5455/jcmr.2023.14.02.13

In attempts to overcome all these obstacles, Instrumental shade determination (ISD) using electronic devices such as colorimeters, spectrophotometers, and intraoral scanners are widely spreading nowadays to help aid in shade selection while capturing a 3-dimensional digital image. This results in a more objective shade selection. These devices provide rapidly quantitative information regarding the shade of the teeth, a broader color spectrum with color values in different formats by analyzing the teeth color using special software, and a better communication between laboratory technicians and clinicians thus saving time and being more convenient when compared to standard visual technique.

To the best of our knowledge, most of the conducted studies compared VSS to ISD using the Vita Easyshade. Limited number of clinical studies compared the intraoral scanners to both VSS and Vita Easyshade. Moreover, most of the studies examined a limited number of examiners including only 2 or 3 (Paul S, Peter A, Pietrobon N, 2002), this is considered critical in that perceptual evaluation and decision of color differences is highly subjective. Besides, only the color of a single tooth was investigated (Bahannan, 2014) at $\alpha=0.05$ and with $P<0.05$ indicating significance. Results Among the participants, 36.3% visually selected the correct shade, and 80.4% did so using the Easy Shade Compact machine. Experience ($P=0.177$) (Fani et al., 2007). In other studies, the only criterion for accuracy and precision was the agreement of the shade tab codes obtained by different repeated measurements (Bahannan, 2014) at $\alpha=0.05$ and with $P<0.05$ indicating significance. Results Among the participants, 36.3% visually selected the correct shade, and 80.4% did so using the Easy Shade Compact machine. Experience ($P=0.177$, this omitted the fact that there might be more than one correct match, considering the threshold of perception (Khashayar et al., 2014).

Thus, the present study compared different shade guides using Visual shade selection (VSS) to Instrumental shade determination (ISD) methods using a larger number of examiners (100). Furthermore, not only color codes were evaluated to determine the precision of each method, but also the results of visual selection were related to the dental students' knowledge.

The null hypothesis is that there is no difference in shade matching Visual shade selection versus Instrumental shade determination. Further null hypotheses included that visual shade selection is influenced by the experience of all participants, and there is a preferred technique for each participant.

MATERIAL AND METHODS

The project took approval from Research Ethical- Committee (FD KAU REC 200-01-21), following guiding principles in the Declaration of Helsinki of WMA. The sample size was calculated using a 0.05 alpha value and 80% power to detect difference of 25% (PiFace, <http://homepage.stat.uiowa.edu/~rlenth/Power/> (checked: 23 November 2021). The common standard deviation within each group was presumed to be 18%. One hundred observers from King Abdul-Aziz University, faculty of Dentistry participated were enlisted to contribute to this study. An informed consent was obtained from participants, and then they were screened using Ishihara color vision test to exclude dyschromatopsia. Each participant was handed a participant instruction sheet. A schematic illustration of all participants with different shade selection techniques is shown in figure.1

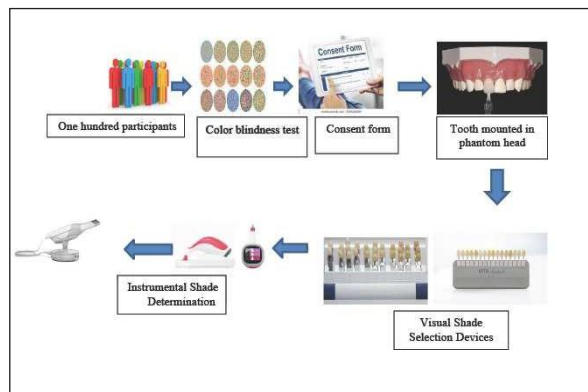


Fig. 1: Schematic diagram of all participants with different shade selection techniques

Participant's Knowledge

All participants were asked to participate in a prepared questionnaire including (a) being either familiar with the general guidelines for shade selections prior to this study or not, (b) being familiar with VITA 3D-Master Shade guide or not, (c) being familiar with the digital shade selection or not, and (d) about their preferred system for shade selection including Vita classical or 3D master.

Visual shade selection

A total 3 shade tabs from VITA Classical shade guides (VITA Zahnfabrik, Bad Sackingen, Germany) and 3 shade tabs from VITA 3D-Master shade guide (VITA Zahnfabrik, Bad Sackingen, Germany) were given codes and randomly distributed. Tabs from VITA Classical included: [A1, A2, B1] (VC). Tabs from VITA 3D-Master included: [1M1, 2M3, 3R1] (V3D). Tabs were selected according to incidence of occurrence in natural teeth together with the available suitable distribution in color space. A viewing booth without any exterior source of light was used with 10:14 inches and 45 degrees angle. A time limit of 5:7 seconds was set for shade matching cycles with observing neutral background during break. Evaluators randomly selected one tab from the 6 masked tabs, then chose "best match". Finally, they recorded it on the provided data sheet. Evaluators repeated this till they completed all 6 tabs.

Instrumental shade determination (ISD)

All instrumental techniques were completed by one investigator. Masked tabs were placed in custom holders for; the intraoral-spectrophotometer VITA Easyshade® Advance 4.0 (VITA Zahnfabrik, Bad Sackingen, Germany) and 3Shape Trios 3 (3Shape, Copenhagen, Denmark). Calibration took place for EasyShade in-between each reading.

Calibration took place for Trios 3 before each cycle of 6 tabs. All ISD cycles were completed in 6 days (1 cycle /day).

Instruments' accuracy was investigated through comparison between instrument readings with the most frequent VSS-control of each shade examined. The percentage of accuracy was recorded by associating number of agreements with comparisons' number.

Statistical analysis

Statistics were based on three planes including the (1) type representing instrumental and visual; (2) Group representing:

VITA Classical, VITA 3D-Master, VITA Easyshade® Advance 4.0, and 3Shape Trios 3; and (3) Subgroup representing: VSS (VITA Classical), VSS (VITA 3D-Master), ISD (EasyShade), ISD (Trios 3), VITA Classical (EasyShade), VITA Classical (Trios 3), VITA 3D-Master (EasyShade), VITA 3D-Master (Trios 3). Statistical analysis was performed with IBM-SPSS Statistics Version 20 for Windows. Data showed non-parametric (not-normal) distribution using Kolmogorov-Smirnov and Shapiro-Wilk tests. Kruskal-Wallis test was used to compare between more than two groups in non-related samples. Mann-Whitney was used to comparison between two groups in non-related samples ($p \leq 0.05$).

RESULTS

Shade Selection

A total of 100 participants contributed to the study 27 females and 73 males with diverse levels of knowledge and proficiency for shade matching. Each participant made six shade match selections (VSS), using VC and VC3D in daylight with a total of 600 observer shade match selections. Shade tabs were recognized instrumentally to confirm the shade tab identification before using. ISD was completed by one investigator: using VEasy and 3Trios. Estimated differences in correct shade selections can be referenced in Figure 2. Regarding type, Kruskal-Wallis test revealed a significantly higher mean of correct selections for Instrumental compared to Visual. Regarding groups, non-significant difference was reported between VC and VC3D ($p=0.96$) in the VSS type. Non-significant difference was found between VEasy and 3Trios ($p=0.41$) in the ISD type. No statistically significant difference was noted with visual selection with the VC relative to instrumental acquisition where VEasy and 3Trios ($p=0.64$). No statistically significant difference was noted with visual selection with the VC3D relative to instrumental achievement where VEasy and 3Trios ($p=0.5$). No statistically significant difference was recorded between instrumental shade selection between VEasy and 3Trios ($p=0.41$) (Figure 2).

Participant's Knowledge

Regarding the response of our participants towards the questions evaluating their knowledge about shade selection guidelines 97 (97%) were familiar while 3 (3%) were not. Regarding their knowledge, 7 (7%) were familiar with different shade guides used in the study, while 2 (2%) did not recognize 3D Master shade guides. Moreover, participants were familiar with the easyshade digital shade selection device. Regarding their preference, 76% of the participants preferred Vita Classical shade guide rather than 3D Master.

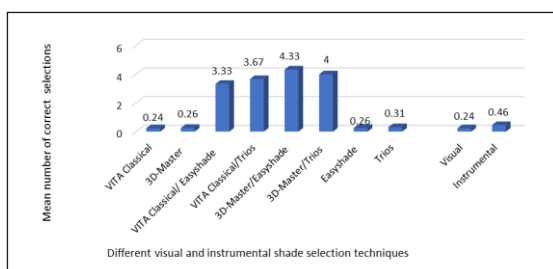


Fig. 2: Bar charts representing the visual and instrumental shade selection techniques

DISCUSSION

VC is the most widely used system in dentistry (Igiel et al., 2017), this comes in accordance with the current research. Although no significant difference was reported in between VC and V3D regarding the correct shade records, participants preferred using VC than V3D with 78% out of the total number participated. Like former studies, most of the participants faced a challenge during the using V3D over VC. This is reflected in the participant response on preferring using the latter (Small, 2006)(Li & Wang, 2007). The increased difficulty can be related to the selection which is routinely performed visually by the aid of dental shade guide. The visual technique has many recognized deficiencies and inaccuracies (Mahshid et al., 2006)(Yilmaz et al., 2011). The control of deficiencies can be made via instrumental technique, which gives a scientific and precise shade reading (Hammad, 2003). In addition, dental personnel and particularly prosthodontic specialists were reported to use Vita Classical colors in their daily work more routinely. (Hammad, 2003) On the contrary, Ghahramanloo et al. reported non-significant difference between both color systems in repeatability. (Ghahramanloo et al., 2008)

Since participants' experience proved to have a great influence on shade selection in some studies (S. Sajini et al., 2022) (Haddad et al., 2009) and visual selection can be taught, one experienced participant served as the reference in the present study. All specialists with more clinical training and experience would be able to realize the importance and the method of shade selection process, Figure 3. The findings also indicated that it is crucial to devote extra time in order to clinically train the students on the method of shade selection process to avoid overlooking the importance of it in their work when they become interns and dentists. In addition, brief courses illustrate the shade selection process can be offered to the training dentists as a part of their continuing education which might assist them to improve and refresh their information in this field (Habib, 2012) (Figure 3).

The null hypothesis that there is no difference in Visual shade selection VSS versus Instrumental shade determination ISD was rejected. Inconsistency of VSS was supported in literatures in many studies. (K. Lehmann et al., 2017) They claim that ISD has increased reliability versus VSS. Paul et al. reported 83% against 26.6% match between instrumental and visual. (Paul S, Peter A, Pietrobon N, 2002). Research proved that digital techniques are more repeatable than visual shade selection. In this study, the repeatability of color determination proved to be significantly better in case of ISD than VSS. 95% of participants were familiar with ISD using VEasy and 3Trios with non-significant difference between them in the correct

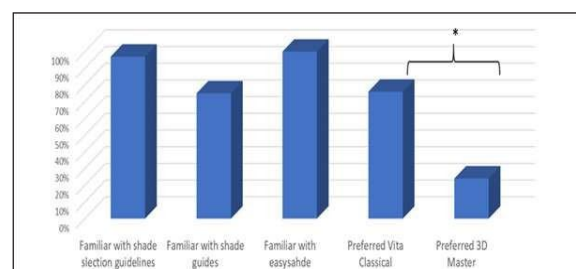


Fig. 3. Bar charts representing the distribution of participants' response to different questions.

shade matching records. This accuracy in data may be affected by the shade recording methodology that was practiced as recommended by the manufacturers. For example, when using VEasy, according to manufacturer’s recommendations that advised repeating shade recording until 2 similar, consecutive measurements of the same tooth are achieved. In this study, measurements were repeated with both instruments, VEasy and 3Shape 6 cycles for 6 days, matching measurements took place. Following this protocol resulted in greater accuracy by facilitating a lot of chances for correct match with the target shade tab

Another reason for perfect accuracy of instrumental selection over visual technique might be the difference in the diameter of the area tested. The instrument probe measures 5 mm diameter in the center of the tooth. This is considered to be very concise compared to the human eye (K. M. Lehmann et al., 2011). Electronic shade selection devices have benefited from their speed and ability to facilitate communication with patients, and dental practitioners.(Brandt et al., 2017) Their high cost is considered their main problem as well as the fact that although they are the most reproducible in shade selection, participants usually found the color codes to be a poor match with the examined tooth. ISD was suggested by reporters to be considered as only complementary for shade selection.(Igiel et al., 2017)

Our results are consistent with the result revealed by Kim et al who found that spectrophotometer tends to provide more reliability and accuracy in the results when using shade selection as the consequences were more objective and more reproducible in comparison with the visual method. (Kim-Pusateri et al., 2009) In the present study, although the VEasy reported non-significant difference with the Trios 3 used in the correct shade selection regarding ISD and non-significant difference also when combined with each of VC and V3D, but at the end it scored more correct shade selections when combined with VEasy.

The intra oral scanner 3Shape Trios reported high scores in correct shade selections when combined with VSS with each of the two used shade guides. This comes in accordance with some researchers who reported that intraoral scanners provided a reliable shade selection technique with visual verification. (Mehl et al., 2017) On the contrary, others reported that shade selection using 3Shape Trios is not an accurate method. (K. M. Lehmann et al., 2010) They reported that both techniques showed comparable results. However, upon combination, extreme accuracy was reported.

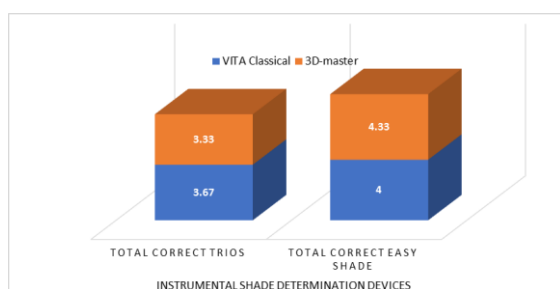


Fig. 4: Bar charts representing repeatability of visual and instrumental shade determination devices in dental shade matching according to the number of correct selections

The literature reported a direct correlation between visual and instrumental methods in determining value dimension. This supports the results of our study, that showed that both the intraoral scanner as well as the spectrophotometer recorded more correct shade selections than when used individually. Figure 4.

The results of the current study look very promising, but further research is advised for example on extracted teeth rather than shade tabs used in the present study. Moreover, an in-vivo study could be designed. Since, digital technology is in a quickly state of turnover, further research is strongly required to evaluate forward progress of the technology.

CONCLUSIONS

The result of this study indicates the promising use of the intra oral scanner 3Shape Trios 3 and dental spectrophotometer VITA Easyshade® Advance 4.0 to be used as alternative methods of shade selection with a VC and VC3D tooth color systems, however, it is recommended to combine visual and digital methods to reach perfect results.

Author Contributions

Conceptualization, H.B.A.-M.; methodology, B.M.E., S.I.S. and S.N.A.; formal analysis, S.I.S.; investigation, B.M.E., S.I.S. and H.B.A.-M.; resources, S.N.A.; data curation, S.I.S.; writing—original draft preparation, Y.H.A. and S.I.S.; writing—review and editing, H.B.A.-M.; visualization, Y.H.A., S.I.S. and H.B.A.-M.; supervision, H.B.A.-M. and S.I.S. All authors have read and agreed to the published version of the manuscript.

Funding

This research didn’t receive any fund.

Institutional Review Board Statement

The research took approval from Research Ethics Committee of Faculty of dentistry, King Abdul-Aziz University (No. 200-01-21) on 27 January 2021 following guidelines of Declaration of Helsinki.

Informed Consent Statement

Informed consent was obtained from all participants contributed in study.

Conflicts of Interest

The authors declare no conflict of interest.

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