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THE EFFICACY AND REPEATABILITY OF THE VITA EASY SHADE  
SYSTEM WHEN COMPARED TO TRADITIONAL VISUAL METHODS OF  
SHADE EVALUATION

by

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## ABSTRACT

### THE EFFICACY AND REPEATABILITY OF THE X-RITE SHADEVISION SYSTEM WHEN COMPARED TO TRADITIONAL VISUAL METHODS OF SHADE EVALUATION

Ali Kanawati, DDS, MBA

The standard method for clinical shade matching is the human eye along with comparative analysis among operators or auxiliary personnel. This study evaluated a new electronic method of clinical shade matching as compared to the standard method that has been almost exclusively used in the past. The Vita Easy Shade system, an electronic method of shade matching, was analyzed for relative accuracy and compared to specific operators' abilities whose effectiveness in color analysis within the realm of dentistry has been determined to be above average by using a simple color screening test. The Vita Easy Shade machine was used on 40 subjects to measure the central region of each patient's tooth #9. Two visual evaluators selected a shade from the same area of tooth #9 for all subjects. Using a 95% score confidence interval, the Vita Easy Shade was predictably accurate between 68% and 91% of the time.

## Chapter I

### Introduction

Today's appearance conscious society is placing an increased emphasis on the demand for not only clinically superior restorations, but esthetically superior as well. Esthetically pleasing restorations include a contour compatible to the shape of the adjacent dentition as well as a shade that is similar to adjacent teeth. Shade matching to adjacent teeth is one of the most important aspects of an esthetically successful restoration.<sup>1</sup> The ability to match the shade of teeth correctly to an available shade guide is a critical factor in this process.

One challenge with shade matching is when the restoration is a single unit anterior case. These types of restorations are the more esthetically demanding. According to a 2002 survey in Dental Products Report, nearly one half of general practitioners change their typical shade taking procedure for single anterior cases. One new form of shade matching is the Vita Easy Shade system, a handheld device that utilizes electronic optical measurements. The manufacturer claims it responds to light in a way similar to the human eye.

The standard method for clinical shade matching is the human eye along with comparative analysis among operators or auxiliary personnel.<sup>2</sup> This study evaluated a new electronic method of clinical shade matching as compared to the standard method that has been almost exclusively used in the past. The Vita Easy Shade system, an electronic method of shade matching, was analyzed for relative accuracy and compared to specific operators' abilities whose effectiveness in color analysis was determined by using a simple color screening test.

## **Purpose**

The relative accuracy of Vita Easy Shade color analysis system will be evaluated by comparing it to human color analysis.

## **Significance of the Study:**

The Vita Easy Shade System is a relatively new system. The standard for clinical shade matching has been the human eye and comparative analysis among operators or auxiliary personnel. This machine will be analyzed for effectiveness when compared to specific operators' abilities whose effectiveness in color analysis within the realm of dentistry has been determined to be above average by using a simple color screening test.

## **Null hypothesis:**

When determining the correct shade for crowns, there is no difference between the accuracy of Vita Easy Shade digital readings versus the accuracy of well trained individuals.

## **Definitions of Terms**

**Trichromatism** - "normal" color vision.

**Normal color vision** - non-color defective vision.

**Monochromatism** - complete color blindness.

**Dichromatism** - condition where an individual is able to see only black or white.

**Anomalous Trichromatism** - ability to see color, however, it is perceived differently than the rest of the population.

**Hue** - The quality of sensation according to which an observer is aware of the varying wavelengths of radiant energy.

**Value** - Relative whiteness or blackness of a color.

**Chroma** - Concentration or strength of hue.

**Color** - characteristic of the light that enters the eye from that object.

**Color rendition** - the accuracy of the reflection of the true colors of an object.

## **Assumptions**

The visual evaluation method is the top standard for clinical shade evaluation and any electronic method of shade evaluation needs to be compared to visual matching.

## **Limitations**

1. Surrounding lighting conditions present during shade matching
2. Eye fatigue
3. gender
4. emotions
5. previous eye exposure
6. object and illuminant positioning
7. variability intrinsic within different shade guides of same manufacturer
8. The Vita Easy Shade machine itself

## **Delimitations**

1. Only the Vita Easy Shade system is being evaluated as an electronic means of shade matching.
2. Only the Vita Classic shade guide is being used as a shade guide to evaluate the accuracy of visual shade matching.

## Chapter II

### Literature Review

Previous authors have recommended that dental students, dentists and auxiliaries be tested for color discrimination.<sup>3,4,5,6</sup> The Farnsworth 100-Hue test has been used in dental research studies as a screening test to rule out defective color vision subjects.<sup>7</sup> The 100-Hue test is a sensitive and accurate test that is used widely and is considered the standard by which most other color discrimination tests are measured.<sup>8,9,10</sup> Its primary purpose is to separate persons with normal color vision into classes of superior, average and low color discrimination. It is not intended to separate color deficiency into a "pass-fail" classification. Disadvantages of this test include that it involves complex calculations, is time consuming, expensive and laborious.

A simple to perform visual test that has been used in dental research studies as a screening test to rule out defective color vision subjects is the Vita-Vita test. The Vita-Vita test has been shown to have a statistically significant positive correlation with the Farnsworth 100-Hue color discrimination test.<sup>11</sup> The Vita-Vita test consists of 2 vita-Lumen shade guides to be matched in pairs according to their tooth shade. For example the C3 shade tab from one shade



guide should be grouped with the other C3. The simple and cost efficient Vita-Vita test is a useful screening tool for color discrimination skills within the realm of tooth color.<sup>11</sup>

Screening for reliable evaluators is a requirement for repeatable and precise clinical shade matching using the visual method.<sup>1,12</sup> This method under optimal conditions can be very effective and predictable. However, optimal conditions can be altered by different variables. There are many different variables involved in matching the shade of a restoration to adjacent teeth.<sup>1,12,13</sup> These inherent problems are multi-factorial and include specific optical characteristics that are different for every tooth that can make shade matching a very challenging procedure. Other variables include surrounding light conditions that are present during the shade matching process. Eye fatigue from exhaustion is another cause of variability that can result in an inaccurate shade match.<sup>1,12,13</sup> Furthermore, the available shade guides used in dentistry do not represent the entire shade range of natural teeth and the shades that are available are not distributed systematically.<sup>1,14</sup>

Studies have shown that gender of individuals with normal vision does not play a role in shade selection.<sup>15</sup> However, color defective vision, an X-linked recessive trait, can cause problems in color discrimination for a percentage of male dentists.<sup>3,5,12,16</sup> Trichromatism is the term used for "normal"

color vision, or non-color defective vision.<sup>13</sup> Color defective vision is grouped into 3 categories.<sup>13</sup> First, Monochromatism is total color blindness which is prevalent in 0.003% of humans. Second, Dichromatism, which is present in 2-3% of males is a condition where an individual is able to see only black or white. Finally, a condition known as Anomalous Trichromatism involves the ability to see color, but it is perceived differently than the rest of the population. This condition affects 5-8% of males.<sup>13</sup>

The prevalence of color defective vision in male dentists was found by Barna et al to be 14%<sup>12</sup>, by Moser et al to be 9.9%<sup>5</sup>, and by McMaugh to be 8.2%<sup>16</sup>. The prevalence of color defective vision in male dentists, being as much as 14%, supports the conclusions of different studies that every dentist as well as dental students along with dental auxiliaries should be tested for color deficient vision as well as their shade matching abilities be evaluated for accuracy.<sup>3,4,12</sup> The ability to consistently match shades accurately can help reduce the number of unsatisfactory results which could lead to costly remakes.

While the visual method is an acceptable method of clinical shade matching under optimal conditions, instrumental shade matching attempts to eliminate some of the variables that are involved in affecting the accuracy and repeatability of the

visual method. Developments in optical electronics and computer technology are making the techniques of electronic shade matching more appropriate for everyday use. Advanced electronic shade matching devices are precise, repeatable, and easily assessed in terms that are visually meaningful. They also though have certain challenges to overcome. In dentistry, results of a colorimetric device can be altered because the standardized illuminating light emitted from the device can be scattered, absorbed, transmitted, reflected, and even displaced in a sideways direction as a result of the translucent optical properties of teeth and dental ceramics.<sup>12</sup>

Seghi concluded that data collected by an electronic shade matching device can be significantly altered by the translucency of the porcelains.<sup>18</sup> Haywood believes some electronic shade matching devices are designed for flat surfaces, rather than the curved, translucent surfaces found on teeth.<sup>19</sup>

The non-uniform color properties of teeth, which include Hue, Value, and Chroma, involve a complex layering of tooth structure and subtle color changes that challenge even the best instruments. This problem of non-uniformity of teeth not only affects results of an electronic shade matching device, but also challenges the human eye as to which portion of the tooth to focus on.

There are currently 5 self contained systems available for clinical shade matching. They include the VITA Easyshade by Vident, Spectroshade by Posey Dental Technology, Shadeye NCC by Shofu, Shadescan by CYNOVAD, and Shadevision by X-Rite. Color measurement is determined either by a colorimeter (Shadye NCC, and Shadevision), spectrophotometer (Vita Easy Shade and Spectroshade), or a proprietary system called "artificial vision" (Shadescan). The Vita EYESHade and Shadeye NCC Have a sensor approximately as large as a handheld curing light. The sensor does not encompass the entire tooth. The Shadevision, Shadescan, and Spectroshade sensors are larger and scan the entire tooth. These 3 systems have shade-mapping abilities based on a variety of shade guide systems. The shade map incorporates the entire tooth, illustrating shade and translucency variations. Some of these systems can also integrate a digital photograph with the final report of the shade of the tooth or adjacent teeth that is sent to the lab.

The Vita Easy Shade does not offer shade matching capabilities. The shade is displayed as a basic shade similar to that of a shade tab chosen from one of the available systems. The tooth can be read three different times and the shade can be broken down into incisal, middle, and gingival shades. This study will focus on evaluating a new electronic shade matching device, the Vita Easy Shade, and compare its

ability to visual matching, the standard method of shade selection.

## Chapter III

### Materials and Methods

The Vita-Vita test was used to identify two visual shade evaluators with a predetermined superior shade matching ability. The individuals were the evaluators to whom the Vita Easy Shade's accuracy was compared. In this study, the original Vita-Vita test was altered to include a third shade guide. The first shade guide, the master guide, was matched per shade using two shade guides as options, instead of only one. This was done to reduce any replacement bias in that if for example A1 was inaccurately chosen for B1 on the master guide, then the correct match for A1 on the master guide will automatically be incorrect because the A1 option was used incorrectly to match B1. This is why adding a third shade guide allows for a more unbiased test. On the other hand, it is feasible to use shade C2 twice to match for example both C2 and C3 of the master shade guide.

Shade tab identification numbers of all shade guides were covered. Tabs of the master guide were color coded with a different color than the other two guides so the master shade guide and the other guides would not be mixed. The individual shade tabs were arranged randomly in two groups on a flat black background and matched to the master guide from the other two guides with all tabs in front of them. All

guides are identical except for the master guide has a different color code than the other two guides. All visual testing was done at the same time of the day under similar light conditions. The same operatory utilizing a color corrected lighting environment was used. Number of errors and frequency of incorrect shades selected were recorded. A recent study using the Vita-Vita test demonstrated repeatability and a significant association within observers\*. Two expert observers were chosen to participate in the vita easy shade matching study.

The Vita Easy Shade machine was used on 40 subjects to measure the central region of each patient's tooth #9. Protocol consisted of mandating virgin non restored teeth without any gross signs of developmental intrinsic staining. The two visual evaluators selected a shade from the same area of tooth #9 for all subjects. The visual evaluators were instructed to focus only on the middle portion of the tooth. The evaluators analyzed the tooth first, and then the tooth was scanned by the machine. The machine tip was placed on the middle third of the tooth for shade analysis.

The accuracy of the Vita Easy Shade was based on the comparison of the results obtained compared to the shade chosen using the visual evaluation method. The Vita Easy Shade relates to the user up to three possible shades for each tooth area

scanned, depending on the variability of the area scanned. For the sake of analytical simplicity, it was considered a match between machine and visual technique if the shade depicted by the evaluators was the same as one of the shades the machine analyzed. All readings on the Vita easy shade instrument were made by the same individual for consistency. Statistical analysis included comparison of the correct matches of the Vita Easy Shade to the standard matching technique, the visual observers. A 95% confidence interval was used in comparative analysis.



## Chapter IV

### Results and Discussion

#### Results

If the shade chosen by the observer was the same as one of the three shades related to the user, then this was considered a match. Within the protocol used, the Vita Easy Shade related the same shade as the visual evaluators 34 out of 40 readings (85%) for both evaluators. Data is presented in table I. Statistical analysis using a score confidence of 95% was used. Using the 95% confidence interval, the Vita Easy Shade was predictably accurate between 68% and 91% of the time.

Table I.

SUBJECT	SHADE CHOSEN BY VISUAL EVALUATOR #1	SHADE CHOSEN BY VISUAL EVALUATOR #2	MACHINE READING 1	MACHINE READING 2	MACHINE READING 3	EVALUATOR #1 MATCH?	EVALUATOR #2 MATCH?
1	B2	B1	B2	B1	A2	1	1
2	C1	C1	C1	D1	C2	1	1
3	C1	C1	C1	C2	D2	1	1
4	B1	B1	B1	N/A	N/A	1	1
5	C1	D2	C3	D2	C1	1	1
6	C4	C4	C4	N/A	N/A	1	1
7	B1	B1	B1	A1	N/A	1	1
8	A1	B1	C2	D2	N/A	0	0
9	A1	B2	B2	A1	B1	1	1
10	B1	B1	B1	A1	N/A	1	1
11	B1	B1	A1	B1	N/A	1	1
12	A2	B2	C2	C3	N/A	0	0
13	C1	C1	C2	C1	C3	1	1
14	B1	B1	B1	N/A	N/A	1	1
15	B1	B1	A1	B1	D2	1	1
16	A1	A1	B2	A1	N/A	1	1
17	C1	A1	C1	C2	D2	1	0
18	D2	B2	C2	D2	C1	1	0
19	A1	A1	A1	B1	D2	1	1
20	C1	B2	C1	B2	C2	1	1
21	B1	B1	A1	B1	D2	1	1
22	A1	A1	D2	C1	A1	1	1
23	D2	C1	B2	C1	A2	0	1
24	B1	D2	A1	B1	D2	1	1
25	A2	D3	A3	B3	D3	0	1
26	C1	D2	B2	D2	C1	1	1
27	B1	B1	B1	A1	N/A	1	1
28	C1	A1	A1	C1	B2	1	1
29	C2	B2	B2	C1	C2	1	1
30	A1	C1	C1	B2	A1	1	1
31	B1	B1	A1	B1	D2	1	1
32	C2	B2	B2	D2	C2	1	1
33	B1	B1	B1	A1	N/A	1	1
34	B2	A2	C2	D4	B3	0	0
35	B1	B1	B1	N/A	N/A	1	1
36	C3	C3	C4	C3	A3	1	1
37	B1	B1	B1	N/A	N/A	1	1
38	C1	C1	A1	D2	C1	1	1
39	B1	B1	B1	A1	N/A	1	1
40	C1	D2	B1	B2	C2	0	0

Vita Easy Shade data compared to evaluator data and match results. A "1" resembles a match while a "0" resembles a non-match.

## Discussion

A "match" existed if the visual evaluator's choice was included in one of the three possible choices the machine gave. When the machine gives more than one option for tooth shade, the operator is left to decide using visual methods for a final shade, rendering the instrument not specific as clinically desired.

The results showed that the machine was accurate 85% of the time. However, at a 95% confidence interval, one can be certain that 95% of the time the machine will not perform below 68% matches, and not above 91% matches relative to the visual method. One can infer that this machine is not absolutely reliable. This machine is not a replacement for traditional methods. However, it is a definite adjunct to visual shade matching.

It was pure coincidence that both visual evaluators received the same number of total matches when compared to the Easy Shade. However, there were inter-operator differences relative to the shades chosen by the Vita Easy Shade. The two shade evaluators had differences among each other a total of four out of 35 shades chosen that did not match the Easy Shade instrument within the protocol used. There are intrinsic differences between the perceptions of operators relative to tooth shade. There are different factors that affect each

visual evaluators' abilities to consistently produce a correct shade match. An attempt to remove some variability within the abilities of the two observers was enforced by using the top two visual evaluators, taking shades during the same time of day and in the same location consistently.

If a practitioner decides to use this adjunctive measure to shade match, this operator should always verify the results of the machine derived shade with a visually derived shade. There were a few cases that the machine was obviously incorrect relative to visual evaluation. This really stresses the need to verify and compare the shade derived by the machine with a visual shade.

## Chapter V

### Summary and Conclusion

#### Summary

Shade matching to adjacent teeth is one of the most difficult and important aspects of an esthetically successful restoration. The Vita Easy Shade system is a relatively new handheld device that uses electronic optical measurements of teeth. While the standard method for clinical shade matching is the human eye, different visual evaluators are able to match shades more or less effectively depending on multiple variables. This is why the altered Vita-Vita test was used to choose the best visual evaluators available. Also, shade matching was performed under similar conditions as well as during the same time of day.

It was considered a "match" if the visual evaluator's choice was included in one of the three possible choices the machine gives. However, when the machine gives 3 different options for the shade of a tooth, this can be confusing.

The results showed that the machine was accurate 85% of the time. However, at a 95% confidence interval one can be certain that 95% of the time the machine will not perform below 68% matches and not above 91% matches to the visual method. One can only infer that this machine is not absolutely reliable.

## Conclusions

As more dentists realize the importance of a scientific approach to color matching in dentistry, manufacturers will continue to research and develop better digital equipment. Currently, the Vita Easy Shade instrument needs further refinement as well as other modifications to deem it more reliable and therefore clinically desirable.

This machine is not a replacement for traditional methods. However, it is a definite adjunct to visual shade matching. The final question, regardless of which system used, visual or electronic, is "Does it match?" The final evaluation system for success or failure will be the patients' and their peers' visual methods. The art of color in dentistry will always rely on individual observation and interpretation, and adjunctive electronic instruments can only enhance this process and attempt to make it more reliable.

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