ISSN: 0975-833X

Available online at http://www.journalcra.com

International Journal of Current Research
Vol. 11, Issue, 03, pp.2066-2071, March, 2019

DOI: https://doi.org/10.24941/ijcr.34623.03.2019

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

RESEARCH ARTICLE

COMPARATIVE STUDY OF VISUAL AND INSTRUMENTAL ANALYSES OF SHADE SELECTION

[1,*]Jouhadi, EM., [1]Amzyl, FZ., [1]Mahdoud, FZ., [2]Hamza, M., [1]Bennani, A. and [1]Andoh, A.

[1]Department of Prosthodontics, Dental School of Casablanca, Hassan II University, Morocco
[2]Department of Pedodontics, Dental School of Casablanca, Hassan II University, Morocco

ARTICLE INFO

Article History:
Received 27th December, 2018
Received in revised form
17th January, 2019
Accepted 06th February, 2019
Published online 31st March, 2019

Key Words:
Visual assessement, Dental color, Shade guide.

**Corresponding author: Jouhadi, EM.*

ABSTRACT

Introduction: Reproducing dental color requires an accurate shade reading, that will thereafter be transferred to the laboratory technician. **Aim:** The purpose of this study is to assess the validity of the visual dental shade-matching, as a conventional method, compared to the spectrophotometric shade-matching. **Materials and Methods:** With visual analysis, 16 prosthodontists examined the middle third of the sound maxillary right central incisor of students using VITAPEN® classical and Vita Tooth- guide 3D-MASTER®. One prosthodontist examined the same teeth using a spectrophotometer. The surveys have been performed within students of Dental Medicine Faculty of Casablanca. They have been conducted by practitioners of the medical staff of the Prosthodontic Department. **Results:** 192 visual shade selection were performed and converted to the Lab* system color. There was no significant difference between the Vita Classic® and Vita 3D Master® shades. However, regarding occupational categories and gender, a significant difference was found. **Conclusion:** According to our study, the visual shade-matching has a low to moderate reproducibility compared to the spectrophotometric reading. The sensitivity and the specificity of visual shade-matching, as well as the kappa index, indicate that the conventional method cannot be considered as a reliable tool. However, the study shows that the Vita 3D Master® shade guide presents more satisfactory results regarding its intrinsic validity, compared to the Vita Classic® shade guide.

Copyright © 2019, Jouhadi et al. *This is an open access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.*

***Citation*: *Jouhadi, EM., Amzyl, FZ., Mahdoud, FZ., Hamza, M., Bennani, A. and Andoh, A.* 2019.** "Comparative study of visual and instrumental analyses of shade selection", *International Journal of Current Research*, 11, (03), 2066-2071.

INTRODUCTION

Reproducing a tooth color requires a precise shade determination, which will be thereafter transferred to the laboratory technician. Different tooth color determination techniques have evolved over time. The use of shade guides as a tool for the color transmission seems to be the most common method in dental practice. The visual color determination is influenced by multiple factors. This has led to the development of instrument shade-matching, based on self-lighting electronic devices. Instrument shade-matching allows a natural tooth color determination, regardless the human and environmental factors, as well as an accurate communication between dentists and technicians. The purpose of this work is to evaluate the validity of the visual shade-matching in comparison with the spectrophotometric shade-matching as a Gold Standard.

MATERIALS AND METHODS

A cross-sectional descriptive study has been conducted within the fixed prosthesis department, at the Dental Treatment and Consultation Center (DTCC) of the Faculty of Dental Medicine of Casablanca (FDMC). The population of the study was composed of 16 examiners from the medical staff department. Divided into 3 professional groups; the examiners prosthesis department. In order to rule out any dischromatopsy (color vision disorder), vision of all medical staff has been tested using the Farnsworth D15® test. Our population did not present any visual alteration. (Fig.1) The color determination was taken among dental students from the FDMC. Only students presenting natural maxillary central incisors, healthy, vital, with no restoration, substance loss nor dyschromia, straight in the arch, have not undergone any whitening, nor orthodontic or prosthetic treatments; were selected for the shade-matching sample. The shade determination was taken on the central area of the first upper incisor's middle third. To optimize the process, the examiners were asked to take their visual survey in the same dental chair, the one closest to the window. This allowed to work under daylight conditions;

- The shade selections were conducted in the middle of the day under a slightly sunny sky.
- The surrounding environment (walls) is an off-white color. All the observed subjects (students) were wearing white medical coats and removed all makeup or colored ornament.
- All students were given a fast polishing to avoid any interference with the color survey.

To exploit the result of the visual shade selection using shade guides in the Delta-E equation, we converted the color values (ex: A2, B1, C2 ...) to their L*a*b* equivalent by scanning them using the Spectro Shade Micro®. The Vita Classic® and Vita 3D Master® shade guides pellets were fixed on a light gray laboratory silicone template (Fig.2). The gray color was chosen for its neutrality to avoid any color cast. Three measurements were made for each pellet. Upon the three measurements taken on the spectrophotometer, the one that is repeated at least twice was assigned to the pellet. In case of discrepancies between the three measurements, the reading is repeated until two measurements are matched. Before starting the study, a pre-survey has been conducted in order to familiarize the medical staff with the measuring instruments. One trained investigator has taken in charge the data collection from the medical staff visual surveys and the students' spectrophotometric readings. The first step of the study was the spectrophotometric readings which was realized on all the students by the same investigator. Every daily first use, the device was calibrated according to the manufacturer's recommendations. The survey was therefore performed on the maxillary central incisor, more precisely in the center of the middle third, and repeated three times in a row. The "L*a*b*" values were collected on Microsoft Excel® spreadsheet. The second step consisted in the collection, by the same investigator, of the medical staff visual shade selections.

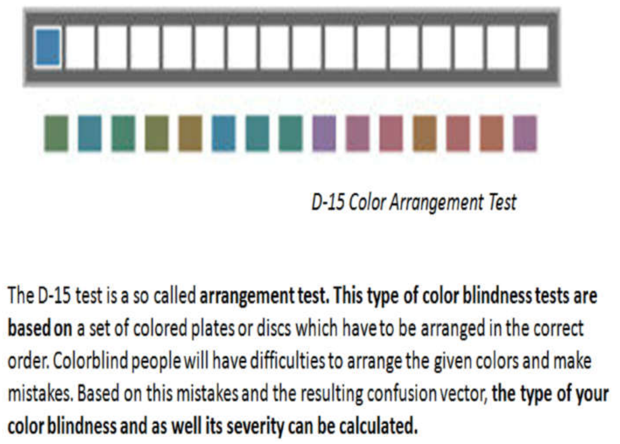

Fig. 1. Farnsworth® Test

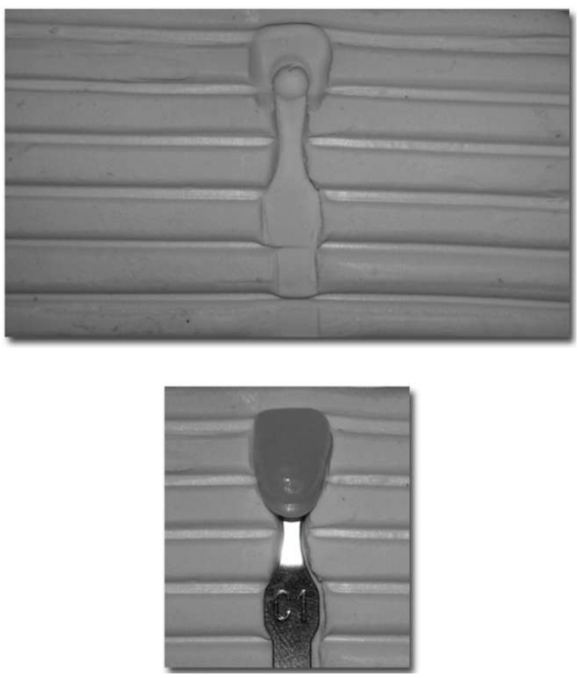

Fig. 2. Pellets on a gray laboratory silicone template

They were divided to visual shade-matching using the Vita Classic® shade guide, and visual shade-matching using the Vita 3D Master®. The final step enabled to synthesize the data and to prepare it for statistical processing. Thus, the value of the Delta E (ΔE), which represents the difference between two stimuli, was calculated for each participant. Visual shade-matching deviations were calculated in comparison with the spectrophotometer results. The ΔE value was calculated by the Euclidean distance between their representative points in the L*a*b* space and calculated by the Delta-E equation via the Excel spreadsheet: ΔE = ((L*1- L* 2) 2 + (a*1 - a*2) 2 + (b*1- b*2) 2) 1/2.

Referring to the literature, the ΔE thresholds were set as follows (Choi *et al.*, 2010)

- ΔE <2: the correspondence between the two stimuli is perfect and the two shade-maching are superimposable.
- 2≤ΔE≤3,7: correct and globally accepted correspondence for the surveys.
- ΔE> 3,7: the difference is visually perceptible and signifies a discrepancy between the two stimuli.

The performance variation by gender or examiner profile (occupational status) was tested by comparing ΔE values using a Chi-square test. The comparisons of ΔE deviations means, for the different shade selection according to the gender and the examiner's profile, were calculated using the Student test and the ANOVA (Analysis of Variance). The comparison of the ΔE deviations according to the shade-matchings was carried out using the Student test for paired samples. The statistical analysis was performed on SPSS 16.0 software.

RESULTS

Our sample consists of 5 professors, 5 specialists and 6 residents (31.25% professors, 31.25% specialists and 37.5% residents), divided into 6 men and 10 women (62.5% women and 37.5% men). All medical staff has completed a total of 192 shade selection.

The results corresponding to the visual shade-matching revealed that with the Vita Classic® shade guide, only 16.7% of the measurements taken by all the staff had a difference ΔE < 2,40. 6 % of the readings had ΔE 2 ≤ΔE ≤ 3.7, and 42.7% of the readings had ΔE> 3.7. Whereas using the Vita 3D Master® shade guide, only 11.5% of the readings had a ΔE <2, 34.4% had ΔE 2 ≤ΔE ≤ 3.7, and 54.2% had ΔE> 3.7. (Table 1/ Table 2). In average, the Vita Classic® shade guide revealed a ΔE mean difference of 3.68 with a standard deviation of 1.58, while the use of the Vita 3D Master® shade guide revealed a ΔE difference average of 4.11 with a standard deviation of 1.78. There was no significant difference between the two shade guides. Similar performance between the Vita Classic® and the Vita 3D Master® has been demonstrated (Table 3).

Based on the ΔE thresholds, there was no significant difference between the examiners, either handling the Vita Classic® or the Vita 3D Master® shade guide. The same results were obtained by comparing the professional groups. (Table 4/ Table 5). Regarding the gender, there was no significant difference between the two sexes, related to the ΔE average, either for Vita Classic® or Vita 3D Master®. However, a significant difference was found based on the gender, in accordance with the ΔE thresholds, when handling the Vita 3D Master®. (Table 6 / Table 7).

Table 1. The distribution of Vita Classic® shade guide ΔE values based on thresholds ΔE

ΔE thresholds	Number	%
ΔE < 2	16	16.7 %
2 < ΔE < 3.7	39	40.6 %
ΔE > 3.7	41	42.7 %
Total	96	100 %

Table 2. The distribution of Vita 3D MASTER® shade guide ΔE values based on ΔE thresholds

ΔE thresholds	Number	%
ΔE < 2	11	11.5 %
2 < ΔE < 3.7	33	34.4 %
ΔE > 3.7	52	54.2 %
Total	96	100 %

Table 3. Concordance rates between VITA CLASSIC® and VITA 3D MASTER® shade guides

	Vita Classic	Vita 3D Master
Mean value	3.685	4.1195
Standard deviation	1.580	1.7858
Median	3.460	3.8500

Table 4. Distribution of ΔE means among the vocational categories regard the use of Vita classic and Vita 3D Master shade guides

	Vita Classic Mean (E.T)	P	Vita 3D Master Mean (E.T)	P
Professors	3.546 (1.557)		4.055 (1.212)	
Specialist doctors	3.626 (1.850)	0.719	4.264 (2.351)	0.868
Residents	3.850 (1.373)		4.052 (1.682)	

Table 5. Concordance rates of ΔE values among the vocational categories

	Vita Classic ®				Vita 3D Master ®			
	ΔE 2-3.7	ΔE <2	ΔE >3.7	P	ΔE 2-3.7	ΔE <2	ΔE >3.7	P
Professors	43.3%	20.0%	41.7%	0.492	46.7%	9.3%	44%	0.0488
Specialist doctors	33.3%	25.0%	36.7%		33.3%	11.1%	55.6%	
Residents	42.9%	9.5%	47.6%		23.3%	13.3%	63.4%	

Table 6. Distribution of ΔE averages based on gender regard the use of Vita classic® and Vita 3D Master® shade guides

	Vita Classic ® Mean (SD)	P	Vita 3D Master® Mean (SD)	P
Female	3.847 (1.442)	0.196	4.303 (2.006)	0.193
Male	3.415 (1.776)		3.812 (1.309)	

Table 7. Concordance rates of ΔE values by gender

	Vita Classic®				Vita 3D Master®			
	ΔE 2-3.7	ΔE <2	ΔE >3.7	P	ΔE 2-3.7	ΔE <2	ΔE >3.7	P
Female	36.1%	30.66%	33.3%	0.017	31.7%	11.7%	56.70%	0.766
Male	43.3%	8.34%	48.3%		38.9%	11.1%	50.0%	

DISCUSSION

The shade guides used during this work (Vita Classic® and Vita 3D Master®) were purchased from an authorized Vita supplier. With the multitude of spectrophotometric devices, we have chosen the most reliable ones described in the literature. It was decided to adopt one of the two brands; the Shadepilote of DEGUDENT® or the Spectroshade by MHT®. The two trade names originate from the same manufacturer. The one available for our study was the Spectroshade of MHT®. All the shade-matchings were undertaken in front of the same window, under a light intensity around 400 lux. The environment was neutral in color. To avoid any color modification due to plaque, a rapid dental polishing was done before the surveys.

Visual shade-matching: No significant difference was found regarding the use of the two shade guides; Vita Classic® and 3D Master®, despite the lack of training for most practitioners regarding the use of Vita 3D Master®. Indeed, (Hassel *et al.*, 2005) mentioned that the shade guide Vita classic® has some limits for practitioners when it comes to complex hues. Theoretically, its evolution to the Vita 3D Master® shifts towards a gain in performance. The Vita 3D Master® shade guide was made based on the analysis of natural tooth shades so that it can cover the most common shades (Paravina *et al.*, 2002). It also covers a large color spectrum compared to the Vita Classic® shade guide. In 2002, Paravina and col. presented comparative results for both shade guides. Vita Classic® contains fewer pellets (16 pellets) compared to the Vita 3D Master® (26 pellets). This gap limits the possibilities and the consistency of the pellets regarding the tooth colorimetric tone, making the shade-matching sometimes random or even impossible. The same observation was reported by (Analoui *et al.*, 2004). Several studies indicate that the manufacture of the Vita Classic® shade guide does not meet the value ranking, despite the fact to be reclassified by this term. It thus remains less suitable compared to the natural vision. By contrast, the Vita 3D Master® is a physiological shade guide, for the manufacturing was based on the value parameter. According to the study of Alsaleh *et al*. (2012) , the cause would probably be related to the multitude of pellets to be analyzed (26 pellets). Indeed, the practitioner is constrained to make several comparisons, to exceed the interval of visual effectiveness analysis. Thus, the eyestrain risk is increased.

Yet, when we understand this shade guide principle and its method of operating, the survey becomes rather fast and efficient. Many studies; such as the investigation of Fani G. *et al*. in 2007 and the Paravina study in 2002, indicate that becoming familiar with the use of 3D Master® shade guide provides the reflex of a rational protocol and the reproducibility rates calculated outperform those of the Vita Classic®.

Visual shade-matching and occupational status

For the use of the Vita 3D Master®, the difference is significant between the three professional groups. The teachers had the highest validity rate, followed by the specialists, and finally the residents. Concerning the 3D Master® shade guide result, it can be due to the experience and the familiarity of its use among professors and specialists. Unlike the residents, for the most part, the present experience was their first contact with the 3D Master® shade guide. The same observation was disclosed in Della Bona *et al*. in 2009, Okubo *et al*. (1998) and Corcodel N in 2012 (10). They have demonstrated the importance of clinical experience in the shade-matching protocol, especially regarding the use of Vita 3D Master shade guide. However, several studies within the literature confirm that there is no correlation between professional experience and the reproducibility shade-matching rate. AlSaleh *et al*. in 2012, have shown in their study that experience did not have a key role in colorimetric perception; students and specialists have all had an identical reproducibility rate of 34%. Haddad *et al*. (2009) have been even able to show that students with little or no experience have achieved similar results as dental experts. Hassel *et al*. (2005) also have compared color perception between patients and practitioners, and there was no significant difference when it comes to professional status.

The "Professional experience" factor, though, does not seem to provide better results. Nevertheless, the influence of professional experience when combined with practitioner's age remains controversial (Esan *et al*., 2006). Physiological changes, eyestrain and vision deficiencies are intertwined with age and experience. Despite the experience gained by years of prosthetic restorations, it seems that the parameters relative to aging decompensate the gain in experience. It remains very difficult to appreciate the effects of each factor isolated. Studies of practitioners age and experience are then compromised by inconsistencies and bias that are too important, which makes it difficult to reliably predict the influence of one or another (Haddad *et al*., 2009).

Visual color survey and gender

Regarding the use of Vita Classic® shade guide, the difference was significant among users from both genders. However, there was no significant difference between the two sexes concerning the use of Vita 3D Master® shade guide. In the literature, the results are controversial. Studies like (Haddad *et al*., 2009) indicate that there is no significant difference between both genders. On the other hand, rare investigations like Donahue *et al*. in 1991 and Esan in 2006 have shown different results, with a high reproducibility rate for men compared to women. Most conducted studies, such as the one carried out by Capa *et al*. in 2010 and the study of Rodriguez *et al*. (2008), report though that women perform better in colorimetric perception than men, which corroborate the results of our study. According to the literature, there is a difference between genders in terms of impaired color visions and this is even correlated to the genetic. Mollo, in 2005 have indicated that men are basically trichromatic, and since women are heterozygous on one of the photo-pigments, they are consequently tetra-chromatic, which is advantageous for women in color vision. The deficiency of color vision is a hereditary recessive disease, transmitted on chromosome X. Women can be carriers and not reached in the majority of cases, while men will have this disease.

This explains why 8% men in overall population have this disorder, compared with only 0.5% to 2% of women, according to the studies (Curd *et al*., 2006; Hammad, 2003). Other studies like Barrett *et al*. 2002 have confirmed that there is no significant difference between the sexes when it comes to visual shade-matching, theoretically, under an optimal daylight. Studies excluding women and men with visual impairment, and women heterozygous carriers (about 15% of the general population), however, have not been able to demonstrate a significant difference between the sexes (Haddad *et al*., 2009). These studies recommended that, when performing a shade-matching, neither sex should be favored, but rather, to screen clinicians for any color vision defect. By contrast, the ability to distinguish colors is equal between men and women who have a normal eyesight; it is then concluded that gender is not a factor of variation in dental shade-matching (Capa *et al*., 2010).

Other factors affecting the visual shade-matching

The lighting

Described as the most important environmental factor that influences the shade-matching protocol. Choi *et al*. in 2010 recommended comparing color under stable and balanced lighting, not only to avoid eyestrain that would reduce the practitioner visual qualities, but especially to ensure observation of the multiple characteristics of the teeth. A stated balanced lighting must associate several types of light or bulbs. In 1970, the company Gamain® was the pioneer of the lighting called "balanced daylight (D65)", which facilitates color distinction without affecting the retinal cell performance.

It also has a color rendering index over 90%. Currently, devices, based on LED lamps, are affordable to practitioners, such as Smile lite® smile line ©, Kerr © Demetron Shade® and Optident © Trueshade®. In (Lasserre and Pineau, 2008). Highlighted the interest of intra-oral cameras during dental shade-matching. They offer very good results for the hue survey. The tooth color determination remains visual and comparative to the usual shade guide samples, but it is carried on a monitor that provide a much-enlarged image. The tooth shade comparison with the shade guide sample is therefore facilitated. This method is an aid to the visual shade-matching and has the advantage to be independent of the ambient light. It only depends on the integrated lighting (LED) within the intra oral camera head.

The environment

The literature highlights the impact of surrounding colors; clothes, ornaments, make-up, walls and the environment, generally speaking, on the visual perception, especially when these colors are contrasted, through the phenomena of simultaneous and successive contrast. In Lasserre *et al*. (2011) presented a comparative study between the visual shade-matching under ambient conditions, and the spectrophotometric shade-matching; that is independent of the environment. The results confirm the influence of the environment on the accuracy of tooth color determination. Other studies. (Chen *et al*., 1985), comparing conventional techniques of shade-matching with the instrument ones, mentioned the direct effect of environmental factors on visual shade-matching. They have shown that instrument shade-matching using a spectrophotometer provides the most precise and accurate shade outcomes.

Dental polishing

Habits such as a systematic prophylactic polishing, despite the fact that it is strongly recommended before tooth shade determination, do not seem to be part of practitioner's habits. According to Llena in 2011only 14.29% of practitioners undertake regular polishing before the tooth shade determination in (Chu *et al*. 2010). Have shown (Analoui *et al*., 2004) that dental polishing finds all its interest in shade-matching protocol. It has been demonstrated that tartar deposits, surface stains and bacterial plaque interfere with the tooth shade by modifying the light behavior on the tooth surface.

From one operator to another

The Tooth shade determination is inconstant and remains operator-dependent. Indeed, the same shade-matching can be perceived differently from one operator to another, and for the same operator from one moment to another. In Meireles *et al*. (2008) have proved the difference in visual shade-matching between several examiners. Gomez *et al*. in 2013 have mentioned that the color perception is personal, referring to the experiences and the learning curve or the pathophysiology (color-vision deficiency, aging of the eye, etc). It is, therefore, the complex result of overlapping phenomena; physiological, psychological and emotional.

With the same operator

- Mood and stress frequently affect the discernment. Furthermore, they cause an internal tension which considerably modifies the eye functioning and its muscles
- Eyestrain
- Consumption of certain medicines
- Successive and simultaneous contrast phenomena
- Repetition, even with the same operator, is deleterious causing retinal saturation (Capa *et al*., 2010; Chu *et al*., 2010).

Conclusion

The visual shade-matching is certainly the most common method for tooth color determination. Yet, it remains very sensitive to many environmental and human factors that can make it completely inaccurate and sometimes useless. In contrast, the instrument method, via spectrophotometers, allows a reliable and objective shade-matching, regardless ambient lighting, environmental factors and human conditions. The present study has evaluated the reproducibility and the validity of the visual shade-matching at the DTCC fixed prosthesis department of the FDMC, in comparison with the « Gold standard » spectrophotometric shade-matching. The results have shown a low to moderate reproducibility for the conventional visual method, compared to the spectrophoto metric shade-matching, under the usual conditions of daylighting within the department. The sensitivity and specificity of the visual shade-matching, as well as the kappa index, indicate that the conventional method can not be considered as a reliable tool. However, the study has demonstrated that Vita 3D Master® shade guide presents more satisfactory results regarding its intrinsic validity compared to Vita Classic® shade guide. Further studies are needed to improve the lighting conditions within the department, as well as the methods commonly used, for an optimal shade-matching that meets the patient needs.

REFERENCES

Alsaleh, S., Labban, M., AlHariri, M. and Tashkandi, E. 2012. Evaluation of self shade matching ability of dental students using visual and instrumental means. *J Dent*., juill 40 Suppl 1:e82-87.

Analoui, M., Papkosta, E., Cochran, M. and Matis, B. 2004. Designing visually optimal shade guides. *J Prosthet Dent.,* 92(4):371‑6.

Barrett, AA., Grimaudo, NJ., Anusavice, KJ. and Yang, MCK. 2002. Influence of tab and disk design on shade matching of dental porcelain. *J Prosthet Dent.,* déc 88(6):591‑7.

Capa, N., Malkondu, O., Kazazoglu, E. and Calikkocaoglu, S. 2010. Evaluating factors that affect the shade-matching ability of dentists, dental staff members and laypeople. *J Am Dent Assoc.,* 1939. janv 141(1):71‑6.

Chen, H., Huang, J., Dong, X., Qian, J., He, J., Qu, X., *et al*., 2012. A systematic review of visual and instrumental measurements for tooth shade matching. *Quintessence Int Berl Ger.,* 1985. 43(8):649‑59.

Choi, J-H., Park , J-M., Ahn, S-G., Song, K-Y., Lee, M-H., Jung, J-Y., *et al*., 2010. Comparative study of visual and instrumental analyses of shade selection. *J Wuhan Univ Technol-Mater Sci Ed.,* févr 25(1):62‑7.

Chu, SJ., Trushkowsky, RD. and Paravina, RD. 2010. Dental color matching instruments and systems. Review of clinical and research aspects. *J Dent.,* 38 Suppl 2:e2-16.

Corcodel, N., Karatzogiannis, E., Rammelsberg, P. and Hassel, AJ. 2012. Evaluation of two different approaches to learning shade matching in dentistry. *Acta Odontol Scand.,* janv 70(1):83‑8.

Curd, FM., Jasinevicius, TR., Graves, A., Cox, V. and Sadan, A. 2006. Comparison of the shade matching ability of dental students using two light sources. *J Prosthet Dent.,* déc 96(6):391‑6.

Della Bona, A., Barrett, AA., Rosa, V. and Pinzetta, C. 2009. Visual and instrumental agreement in dental shade selection: three distinct observer populations and shade matching protocols. *Dent Mater Off Publ Acad Dent Mater.,* févr 25(2):276‑81.

Donahue, JL., Goodkind, RJ., Schwabacher, WB. and Aeppli, DP. 1991. Shade color discrimination by men and women. *J Prosthet Dent*., Mai, 65(5):699‑703.

Esan, TA., Olusile, AO. and Akeredolu, PA. 2006. Factors influencing tooth shade selection for completely edentulous patients. *J Contemp Dent Pract.,* 1 nov 7(5):80‑7.

Fani, G., Vichi, A. and Davidson, CL. 2007. Spectrophotometric and visual shade measurements of human teeth using three shade guides. *Am J Dent.,* juin 20(3):142‑6.

Gómez-Polo, C., Gómez-Polo, M., Celemin-Viñuela, A. and Martínez Vázquez De Parga, JA. 2014. Differences between the human eye and the spectrophotometer in the shade matching of tooth colour. *J Dent*., juin 42(6):742‑5.

Haddad, HJ., Jakstat, HA., Arnetzl, G., Borbely, J., Vichi, A., Dumfahrt, H., *et al*., 2009. Does gender and experience influence shade matching quality? *J Dent.,* 37 Suppl 1:e40-44.

Hammad, IA. 2003. Intrarater repeatability of shade selections with two shade guides. *J Prosthet Dent.,* janv 89(1):50‑3.

Hassel, AJ., Koke, U., Schmitter, M., Beck, J. and Rammelsberg, P. 2005. Clinical effect of different shade guide systems on the tooth shades of ceramic-veneered restorations. *Int J Prosthodont.,* 18(5):422‑6.

Laserre jean-F. and Pineau, S. 2008. Le relevé de la couleur : Quelles sont les évolutions instrumentales ? *Fil Dent.,* nov _37_(14).

Lasserre, J-F., Pop-Ciutrila, I-S. and Colosi, H-A. 2011. A comparison between a new visual method of colour matching by intraoral camera and conventional visual and spectrometric methods. *J Dent.,* déc;39 Suppl 3:e29-36.

Llena, C., Lozano, E., Amengual, J. and Forner, L. 2011. Reliability of two color selection devices in matching and measuring tooth color. *J Contemp Dent Pract*., 1 janv 12(1):19‑23.

Meireles, SS., Demarco, FF., dos Santos I da, S., Dumith, S de, C. and Bona, AD. 2008. Validation and reliability of visual assessment with a shade guide for tooth-color classification. *Oper Dent.,* avr;33(2):121‑6.

Mollon, J. 2006. Monge: The Verriest lecture, Lyon, July 2005. Vis Neurosci. août 23(3‑4):297‑309.

Okubo, SR., Kanawati, A., Richards, MW. and Childress, S. 1998. Evaluation of visual and instrument shade matching. *J Prosthet Dent.,* déc 80(6):642‑8.

Paravina, RD. 2002. Evaluation of a newly developed visual shade-matching apparatus. *Int J Prosthodont.,* déc 15(6):528‑34.

Paravina, RD., Powers, JM. and Fay, R-M. 2002. Color comparison of two shade guides. *Int J Prosthodont.,* févr 15(1):73‑8.

Rodríguez-Carmona, M., Sharpe, LT., Harlow, JA. and Barbur, JL. 2008. Sex-related differences in chromatic sensitivity. *Vis Neurosci.,* Juin, 25(3):433‑40.

****