Shade Selection Practices Amongst Clinical Dental Students in South Western Nigeria

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ABSTRACT

Objective: Shade selection is crucial in satisfying aesthetic demands of patients during cosmetic dental treatment. It is important to nurture and evaluate this act in students as future dental professionals. This study aimed to evaluate the understanding and practice of tooth shade matching amongst dental students.

Methods: A descriptive cross-sectional study was carried out in South-Western Nigeria. A structured, self-administered questionnaire was given to clinical dental students to garner information on socio-demographics, knowledge and practice of shade selection. The resulting data were statistically tested using chi-square with p-value ≤ 0.05 indicating significant level.

Results: There was 76.5% response rate to the questionnaires with the male subjects accounting for 52.3%. The mean age of participants was 24.2 ± 2.4 years. Majority (40.9%) did not know the ideal time required for shade selection. Most (57.9%) students used visual/manual method in shade selection but 63.6% of these did not know the name of the shade guide used. Majority (80.8%) select the shade before commencing restorative procedure. Less than half (36.4%) of participants performed tooth shade matching in 3 segments (from incisal-third to cervical-third) while 54.5% considered tooth shade as a single uniform colour. Most students, 67.4% had a fair knowledge of shade matching while 13.6% practiced good shade matching technique for restorations/prosthesis. There was a statistically significant difference (p=0.022) between shade selection practice and the clinical training levels of students.

Conclusion: The dental students had a fair knowledge about the principles of shade selection but lack the clinical know-how.

Keywords: Dental students, shade selection, practice.

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INTRODUCTION

Over the past decades, aesthetics has assumed a new prominence in modern dentistry, appearing to portray an individual's personality. Hence establishing a natural dental appearance now constitutes a vital task in the specialties of prosthodontics and conservative dentistry.[1] The four basic determinants of optimum aesthetic treatment outcome are: position, contour, texture, and colour of the restoration.[2]

Colour of restoration or shade selection is the determination of the colour and other attributes of appearance of an artificial tooth or set of teeth in a given individual.[3,4] It is crucial in satisfying the aesthetic desire of patients which is harmoniously incorporated into the patient's natural dentition.[5]

Generally, shade is a combination of three factors: hue, value and chroma. Hue is what distinguishes one colour from another; value indicates the lightness of a colour ranging from pure black to pure white while chroma is the degree of colour saturation that describes the strength, intensity or vividness.[6]

Essentially, the process of shade matching is carried out using the visual and/or instrument methods.[2] The visual method of shade determination is commonly used in the clinics and training institutions. It is a quick and cost effective method. When using the visual method, the tooth and the shade guide should be viewed simultaneously under the same lighting conditions.[7] It relies greatly on the clinician's physiologic and psychologic responses to radiant energy stimulation. However, the shortcoming of the visual method is that it is inconsistent and error prone.[2] Munsell colour system is a popular visual method for shade selection which focuses on hue, value and chroma parameters. The value ranges from white to black and it is determined by selecting the closest tab that corresponds with the lightness or darkness of the colour.[2,8] A new and improved visual shade-matching apparatus, Shademat visual+ has been introduced to clinical practice.[9] However, there is still a great need for a more scientific and consistent means of visual shade matching in aesthetic dental practice. Variables such as external light conditions, experience, age, colour blindness and fatigue of the human eye usually subject visual shade selection method to inconsistencies and bias.[2,10] Other factors that may influence clinical judgement include the make-up worn by patients, colour of the patients' cloth and the surrounding. These usually result in errors, in the absence of necessary precautions.[11] Hence, students as well as clinicians must appreciate their roles; in meeting the aesthetic demands and expectations of patients especially when placing anterior restorations.[3]

The instrument shade matching method on the other hand, is objective, rapidly obtained, easily quantified and can be replicated. These strong and desirable features eliminate the inaccuracies associated with the visual method.[2] Currently, there are several available technology-based shade matching devices, these are colorimeters, spectrophotometers, digital colour analyzers /digital cameras, and instruments that combine these technologies.[9] Digital camera, with recent advances in technology and widespread use of digital images uses the image of the tooth that is compared with standardized images and then transferred to the computer for measurement. It helps in producing a harmonious restoration.[12] The

digital camera is very efficient and straightforward, it is reliable and reproducible.[2,13] The spectrophotometer is an accurate scanning device (e.g. VITA Easyshade Compact® and CrystalEye®) that measures the amount of visible radiant energy reflected or transmitted by an object.[2,14] The filter tristimulus colorimeters (e.g. ShadeEye Natural Colour Concept Chroma Meter) are consistent and sensitive in shade matching but they are not as accurate as spectrophotometers.[2,15] Despite the objectivity of the different instrument methods available for dental shade matching, its use is limited by equipment cost and operational difficulties.[2]

Dental students may experience greater difficulty in tooth shade selection,[16] unlike qualified dentists. It is therefore important that as part of the future workforce, students must be trained to confront the challenges of good shade matching for restorations and prosthesis in patients. This study therefore aims to provide information on the knowledge and practice of shade matching for restorations and prosthesis by dental students. The information garnered will assist in improving the quality of training in Nigerian dental schools.

MATERIALS AND METHODS

This was a descriptive, cross-sectional study which was undertaken in two South Western states in Nigeria. Ethical approval was obtained from Lagos University Teaching Hospital Ethics Committee before the study commenced. The study was conducted in full accordance with ethical principles including the World Medical Association Declaration of Helsinki (version 2008). The study participants were clinical dental students in the 5th and or 6th (final) year of study performing relevant clinical procedures in Restorative clinics. All qualified dentists including House officers were excluded from the study. A pilot study was carried out among House officers to determine the clarity of the questionnaire. Structured questionnaires designed to elicit information on socio-demographics, knowledge, and practices of shade matching were administered to all 5th and 6th year clinical dental students that consented to participate in the study. The participants' responses to questions on knowledge and practice of shade selection were graded. Grades were assigned in the knowledge section based on the percentage of overall correct answers given, grade of poor was assigned to ≤50 per cent, fair was assigned if between 50 and 80 per cent, and good was assigned to ≥ 80 per cent. Grades were also assigned based on the percentage of overall correct answers given in the

practice section, grade of poor was assigned to < 70% and good was assigned to ≥ 70%.

Statistical analysis was performed using the Statistical Package for Social Sciences for Windows version 20.0 (Armonk, NY: IBM Corp. USA). Descriptive statistics was generated and the Chi-square test of association was used where appropriate. Difference was taken as statistically significant at the level of P<0.05.

RESULTS

Two hundred and thirty questionnaires were distributed among the participants, with the retrieval of 176 questionnaires accounting for a response rate of 76.5%. There were 92 (52.3%) males and 84 (47.7%) females. The age range was 20 to 33 years with the mean age being 24.2 ± 2.4 years. Majority 118 (67%) of the participants were final (6th) year students (Table 1). Only 69 (39.2%) of the participants, responded that skill of operator is vital for shade selection. Majority 143 (81.3%) of participants, knew that hue plays a major role in shade selection, however, only 65 (36.9%) and 30 (17%) respectively knew the essence of chroma and value during tooth shade selection. Seventy-two (40.9%) participants were unaware of the ideal time for shade selection (Table 2). Those that reported the use of visual method of shade selection in their dental school/teaching hospital accounted for 61.4% of the participants while 49 (27.8%) did not know the type of the shade guide in use at their clinics. Majority of the participants were aware that age, 156 (88.6%); and gender, 151 (85.8%), played a significant role in shade selection (Table 2).

Table 1: Socio-demographic characteristics and source of knowledge of shade selection among the respondents

Variable	Frequency (n)	Percent (%)
Gender		
Male	92	52.3
Female	84	47.7
Total	176	100.0
Age (years)		
20-23	74	42.0
24-27	85	48.3
≥28	17	9.7
Total	176	100.0
Mean age ± SD 24.2 ± 2.4		
Ethnic group		
Yoruba	127	72.2
Hausa	2	1.1
Ibo	34	19.3
Others	13	7.4
Total	176	100.0
Level of study		
500	58	33.0
600	118	67.0
Total	176	100.0
Have you ever been taught shade selection officially in school?		
Yes	166	94.3
No	10	5.7
Total	176	100.0
If yes, by what method?		
Lectures	73	44.0
Informally in clinic	53	31.9
Both lectures and clinic	40	24.1
Total	166	100.0

SD = Standard deviation

Table 2: Knowledge about shade selection among the respondents

Variable	Frequency (n)	Percent (%)
Vital in shade selection (*multiple response*) n=176		
Single observer	143	81.3
Knowledge	126	71.6
Skill	69	39.2
Talent	13	7.4
Don't know	10	5.7
Plays a major role in shade selection (*multiple response*) n=176		
Hue	143	81.3
Chroma	65	36.9
Value	30	17.0
Radiopacity	16	9.1
Radiolucency	16	9.1
Don't know	10	5.7
Ideal time required for shade selection		
Within 5 seconds	28	15.9
5-10 seconds	41	23.3
11-15 seconds	21	11.9
16-20 seconds	14	8.0
I don't know	72	40.9
Methods for taking shade selection (*multiple response*) n=176		
Visual (manual)	156	88.6
Instrumental	79	44.9
Visual and instrumental	88	50.0
I don't know	4	2.3
Method used in your School/Clinic?		
Visual (manual)	108	61.4
Visual and instrument	19	10.8
I don't know	49	27.8
Which variables affect the perception of tooth colour? (*multiple response*) n=176		
Light source	161	91.5
Eye fatigue	87	49.4
Adjacent structures	90	51.1
Operatory walls/ Environment	73	41.5
Surrounding clothes	40	22.7
Make-up of the patient	48	27.3
I don't know	6	3.4
Which tissues can influence the shade selected (*multiple response*) n=176		
Gums	116	65.9
Lips	83	47.2
Palate	5	2.8
Floor of the mouth	6	3.4
Nose	2	1.1
Facial skin	71	40.3
I don't know	26	14.8
Age of patients play an important role in shade selection (n=176)		
Yes	156	88.6
No	11	6.3
I don't know	9	5.1
Gender of patient plays an important role in shade selection(n=176)		
Yes	151	85.8
No	25	14.2

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One hundred and forty two (80.8%) participants claimed that they select the shade before the start of the restorative procedure while 149 (84.7%) reported occasional difficulty with shade selection process.

Majority 96 (54.5%) reported selecting a single shade tab during the matching of tooth shade while an almost equal proportion 95 (54%) reported they had never filled a shade distribution chart (Table 3).

Table 3: Practice of shade selection among the respondents

Variables	Frequency (176)	Percent (%)
Time of shade selection		
During restorative procedure	26	14.8
Before restorative procedure	142	80.7
After restorative procedure	8	4.5
Tooth used for shade selection		
Adjacent tooth	111	63.1
Contralateral same tooth type	9	33.5
Opposing tooth	3	1.7
Premolars	3	1.7
Method used		
Visual (manual)	143	81.3
Instrumental (mechanical)	8	4.5
Visual and instrumental	10	5.7
Light used for shade selection		
Dental chair light	9	5.1
Natural daylight	164	93.2
Fluorescent light	3	1.7
Consider skin colour		
Always	44	25.0
Sometimes	93	52.8
Never	39	22.2
Female patients to remove lipstick		
Always	58	33.0
Sometimes	70	39.8
Never	48	27.3
Place bib over bright clothing		
Always	48	27.3
Sometimes	69	39.2
Never	59	33.5
Perform oral prophylaxis		
Always	87	49.4
Sometimes	71	40.3
Never	18	10.2
Eye always at the same level with the patient's tooth		
Yes	104	59.1
No	72	40.9
Portions of the crown segment of tooth considered during shade matching		
As a single unit	96	54.5
As two halves	15	8.5
In 3 portions: Cervical, middle and incisal third	64	36.4
I don't know	1	0.6
Routinely fill a shade distribution chart		
Always	21	11.9
Sometimes	60	34.1
Never	95	54.0

Overall, only 28 (15.7%) had a good knowledge of shade selection while 24 (13.6%) practiced shade matching for restorations and prosthesis correctly (Tables 4 and 5). Table 5 revealed that there was a statistically significant difference (p=0.022) between

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shade selection practice and the clinical training levels of students.

Table 4: Test of association between knowledge of students and socio-demographic variables

Variable	Knowledge status			χ2	df	P-value
	Poor	Fair	Good			
Gender				1.203	2	0.548
Male	22(23.9)	58(63.0)	12(13.0)			
Female	18(21.4)	50(59.5)	16(19.0)			
Total	40(22.7)	108(61.4)	28(15.9)			
Age (years)				4.738	4	0.315[F]
20-23	19(25.7)	42(56.8)	13(17.6)			
24-27	16(18.8)	54(63.5)	15(17.6)			
≥28	5(29.4)	12(70.6)	0(0.0)			
Total	40(22.7)	108(61.4)	28(15.9)			
Ethnic group				11.236	6	0.100[F]
Yoruba	26(20.5)	82(64.6)	19(15.0)			
Hausa	1(50.0)	1(50.0)	0(0.0)			
Ibo	13(38.2)	16(47.1)	5(14.7)			
Others	0(0.0)	9(69.2)	4(30.8)			
Total	40(22.7)	108(61.4)	28(15.9)			
Level of study				2.557	2	0.278
500	17(29.3)	34(58.6)	7(12.1)			
600	23(19.5)	74(62.7)	21(17.8)			
Total	40(22.7)	108(61.4)	28(15.9)			

χ2 = Pearson's Chi-square test, [F]= Fisher's exact

DISCUSSION

The sample population in this study was representative of dental students in South-West Nigeria. The highest proportion of the respondents belonged to the 24-27 years age group and majority were in final year of study. There was an almost equal proportion of both genders. Dental students are a relevant population to conduct a survey on shade matching abilities because they fall into the younger adult age group category and this subset of dental operators would generally lack experience in shade selection.[8,17] In aesthetic dentistry, shade selection is key to re-establishing a natural appearance of restored teeth.[18] It is only when the significance of hue, chroma and value is properly understood that the illusion of reality can be achieved. This will help in selecting the most precise shade for dental restorations of patients.[19,20]

The results from this study showed that the knowledge of shade selection of the participants revealed diverse answers on the basic knowledge on colour science. Majority of the study participants did not know that value and chroma play a major role in shade selection, this revealed the need for increased knowledge. Majority (84.1%) of the students did not know the ideal time required (≤5 seconds) for shade selection. This is in agreement with the findings of Alruwaili et al.[21] They reported that 80.2% of their respondents wrongly reported the ideal time for shade selection. Other studies also reported that staring at the teeth for more than five seconds can cause hue accommodation, and may lead to errors.[2,6,22]

Table 5: Test of association between practice of students and socio-demographic variables

| Variable | Practice Status | | χ2 | df | P-value |
	Poor	Good			
Gender			1.253	1	0.263
Male	82(89.1)	10(10.9)			
Female	70(83.3)	14(16.7)			
Total	152(86.4)	24(13.6)			
Age			5.711	2	0.058[F]
20-23	68(91.9)	6(8.1)			
24-27	68(80.0)	17(20.0)			
≥28	16(94.1)	1(5.9)			
Total	152(86.4)	24(13.6)			
Ethnic group			3.348	3	0.341[F]
Yoruba	106(83.5)	21(16.5)			
Hausa	2(100.0)	0(0.0)			
Ibo	32(94.1)	2(5.9)			
Others	12(92.3)	1(7.7)			
Total	152(86.4)	24(13.6			
Level of study			5.262	1	0.022*[F]
500	55(94.8)	3(5.2)			
600	97(82.2)	21(17.8)			
Total	152(86.4)	24(13.6)			

χ2 = Pearson's Chi-square test, * Statistical significance; p<0.05, [F]= Fisher's exact

The perception of shade can be affected by different factors such as dentist's experience, patients make up or clothing and surrounding/ background of the operating room.[2] This study revealed that majority of the students did not know factors that can affect tooth colour perception during shade selection. This is similar to another study that reported majority of the student did not consider the effects of the surrounding objects like patients' clothing (67.1%) and presence of lipstick (75.7%) on the shade selection.[19]

Though the students in this study were taught by didactic lectures and informal chair side teachings in the clinic, the teaching was not translated to knowledge judging by their answer to some shade selection protocol. Studies,[7,22] have reported that shade matching ability of dental students can be positively improved by colour education with an implication of improved restorative esthetic procedures. Another study reported that education and knowledge of colour science combined with clinical experience improved students' abilities in colour matching.[23] The findings in this study underscores the need for more concerted effort on training and implies that more emphasis should be placed on colour science and shade matching protocol when teaching dental students.

There are some practices that should be carried out before shade selection, these include oral prophylaxis, draping brightly coloured clothes, lipstick removal, ensuring proper lighting conditions, resting the eyes by focusing on a greyish-blue surface just before the shade selection process to ensure a balance of all the colour sensors of the retina and also to re-sensitize the eye to the natural tooth colour).[2] The findings of our study revealed that, less than half (49.4%) of the students carried out oral prophylaxis routinely before shade selection. This is similar to another study that reported only 34.3% of their student always performed oral prophylaxis before selecting the tooth shade.[19] Other studies reported that teeth to be matched, should be cleaned of all the debris and stains before shade selection is carried out.[7,24,25] Other practices of shade selection in this present study revealed that majority of the participants 164 (93.2%), conduct shade selection in natural daylight. Though natural light is suggested to be the ideal light source for tooth shade matching, but this can be affected by weather conditions. A study reported that the use of correcting light instead of natural light significantly improved the shade matching performance of students.[17] A study also proposed that tooth shade should preferably be determined, before turning on the operatory light, in

bright daylight or under standardized lamps.[19] Another study recommended that, due to changes in daylight conditions, an affordable source of light like white daylight energy saver lamps can be used.[26]

More than half (59.1%) of the participants made shade selection with the eye at the same level with the patient's tooth. This is in contrast to another study which reported that, less than half (30%) of the study population, select tooth shade at eye level.[19] Studies have reiterated the importance of shade selection at similar eye level with patient and at arm's length. This allows the central part of the retina (the most sensitive part of the retina) to be used during shade selection.[2,12,27] Therefore, training dental students to use this approach will improve their shade taking accuracy.

An important way to prevent error is to perform shade selection at the beginning of the treatment. Studies have shown that dehydration of the teeth occurs during treatment and may cause poor shade selection, hence the need to take shade prior to commencement of the procedure.[2,22] The result of this study revealed that most of the students (80.7%) perform shade selection at the beginning of the treatment.

Majority of the students (81.3%), use only the visual/manual method during shade selection. This involves viewing the tooth and shade guide simultaneously. This was not surprising because the manual method is the most frequently used in dentistry.[11] Other studies have corroborated this because, instrumental method of shade selection is usually expensive, complicated and cumbersome to use.[28-30]

The operatory wall and the environment around the teeth like lips, patients clothing can affect the saturations and the hues perceived. In this study, few students (33%) consider both bright clothing or request their female patients to clean off lipstick before proceeding with the shade selection. This is in agreement with a similar study that reported, most students don't consider the surrounding when performing shade selection.[19]

More than half of our study participants considered the tooth as a single unit when selecting the shade and majority did not fill a shade distribution chart during the shade selection. This finding is similar to that of another study.[19] Studies have advocated the use of shade distribution chart, emphasizing the gradation of color from the cervical to the incisal area. They noted the incisal colour is generally translucent and influenced by the background. The use of shade distribution chart helps to make the final shade that is closest to the natural teeth.[31,32] Shade

selection should therefore be performed separately for different regions of the tooth surface and thereafter, recorded on a shade distribution chart.

The reported significant difference in shade selection practice in our study between students in the penultimate and final year classes was expected. This is because advancement in educational level is expected to enhance knowledge and clinical ability in treatment procedures. Similarly, some studies reported improvement in shade matching ability with the level of dental education and senior students had an improved clinical practice of shade selection than the junior students.[20,33,34] In contrast, a study reported the tooth colour matching ability of the students was not significantly associated with the level in dental school.[35] Samra et al.[23] reported that previous colour education and training in shade matching improved shade matching ability of dental students.

CONCLUSION

It can be concluded that the dental students had a fair knowledge about the principles of shade selection but exhibited poor practices during shade determination. Greater effort is needed to improve the students' understanding and ensure they perform the procedure properly to achieve accurate and satisfactory aesthetics.

The findings of this study revealed, there is a need for revision of the undergraduate dental curriculum as regards to colour science and placing adequate emphasis on the identified deficiencies of the current teachings of the principles that should be followed to obtain accurate results when performing shade matching procedures. This will broaden and improve the knowledge of the students which would impact their clinical practice.

It is therefore paramount that dental students have a complete understanding of the visual and instrumental shade selection approach in dentistry to ensure accurate colour assessment and be able to provide patients with satisfactory treatments. Nigerian dental schools need to provide a variety of shade matching devices for adequate aesthetic dental training and ensure close supervision of dental students for proper shade selection.

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Conflict of Interest

None declared.

REFERENCES

1. Albashaireh ZS, Alhusein AA, Marashdeh MM. Clinical assessments and patient evaluations of the esthetic quality of maxillary anterior restorations. Int J Prosthodont. 2009; 22: 65–71.

2. Agrawal VS, Kapoor S. Color and shade management in esthetic dentistry. Univ Res J Dent. 2013; 3: 120-127.

3. LuBovich R. Smile designing for the malcontent patient. Compend Contin Educ Dent. 2010; 31: 412–416.

4. The glossary of prosthodontic terms. J Prosthet Dent. 2005; 94: 10-92.

5. Scientific and artistic principles of tooth shade selection. A review. Available from: https://www.researchgate.net/publication/2623 72270_Scientific_and_artistic_principles_of_too th_shade_selection_A_review Accessed Mar 2019.

6. Fondriest J. Shade matching in restorative dentistry: the science and strategies. Int J Periodon Rest Dent. 2003; 23: 467-480.

7. Joiner A. Tooth colour: a review of the literature. J Dent. 2004; 32: 3-12.

8. Della Bona A, Barrett AA, Rosa V, Pinzetta C. Visual and instrumental agreement in dental shade selection: Three distinct observer populations and shade matching protocols. Dent Mater. 2009; 25: 276-281.

9. Paravina RD. Evaluation of a newly developed visual shade-matching apparatus. Int J Prosthodont. 2002; 15: 528-534.

10. Watts A, Addy M. Tooth discolouration and staining: a review of the literature. Br Dent J. 2001; 190: 309-316.

11. Lee YK, Yu B, Lim JI, Lim HN. Perceived color shift of a shade guide according to the change of illuminant. J Prosthet Dent. 2011; 105: 91-99.

12. Chen H, Huang J, Dong X, Qian J, He J, Qu X, Lu E. A systematic review of visual and instrumental measurements for tooth shade matching. Quintessence Int. 2012; 43(8):649-59.

13. Cal E, Sonugelen M, Guneri P, Kesercioglu A, Kose T. Application of a digital technique in evaluating the reliability of shade guides. J Oral Rehabil. 2004; 31: 483-491.

14. Da Silva JD, Park SE, Weber HP, Ishikawa-Nagai S. Clinical performance of a newly developed spectrophotometric system on tooth color reproduction. J Prosthet Dent. 2008; 99: 361-368.

15. Tung FF, Goldstein GR, Jang S, Hittelman E. The repeatability of an intraoral dental colorimeter. J Prosthet Dent. 2002; 88: 585-590.

16. Vigneshwar T, Sambandam M, Sindhu R. Knowledge, attitude, and practice of dental students and practitioners on shade matching of anterior teeth. J Adv Pharm Edu Res. 2017; 7: 367-370.

17. Nakhaei M, Ghanbarzadeh J, Keyvanloo S, Alavi S, Jafarzadeh H. Shade matching performance of dental students with three various lighting conditions. J Contemp Dent Pract. 2013; 14: 100-103.

18. Marcucci B: A shade selection technique. J Prosthet Dent. 2003; 89: 518-521.

19. Habib SR. Awareness of tooth shade selection principles among dental students, interns, general dentists and specialists. Pak Oral Dent J. 2012; 32: 549-555.

20. Winkler S, Boberick K, Weitz K, Datikashvili I, Wood R. Shade matching by dental students. J Oral Implantol. 2006; 32: 256–258.

21. Alruwaili MN, Alanazi AO, Albilasi RM, Alruwaili YK, Alanazi AH, Almusieb FF. Knowledge, attitude and practice of dental students, practitioners and specialist on composite shade matching in Al-jouf, KSA. Egyptian J Hosp Med. 2018; 72: 4017-4020.

22. Miller, LL.Esthetic dentistry development program. J Esthet Dent. 1994; 64(2): 47-60.

23. Samra APB, Moro MG, Mazur RF, Vieira S, De Souza EM et al. Performance of Dental Students in Shade Matching: Impact of Training. Esthet Restor Dent. 2017: 29: 24-32.

24. Alvin G. Description of color, color-replication process, and esthetics. In: Rosenstiel SF, Land MF, Fujimoto J, eds. Contemporary fixed prosthodontics. 4th ed. New Dehli: Elsevier; 2007:709-739.

25. Shammas M, Alla RK. Color and shade matching in dentistry. Trends Biomater Artif Organs. 2011; 25: 172-175.

26. Ahmad S, Habib SR, Azad AA. Scientific and artistic principles of tooth shade selection: A review. Pak Oral Dent J. 2011; 31: 222-226.

27. Shillingburg HT, Hobo S, Whitesett LD, Jacobi R, Bracketts SE, Fundamentals of Fixed Prosthodontics: Esthetic considerations, 3rd ed.

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Quintessence publishing co. Inc. Chicago; 1997: 419-432.

28. Smitha AJ, Savitha PN. Shade matching in aesthetic dentistry–from past to recent advances. J Dent Oral Care Med. 2017; 3: 1-9.

29. Shajahan PA, Raghavan R, Kunjumon N. The Perfect Match: Recent Advances in Shade Matching. Int J Dent Med Sci Res. 2019; 3: 9-14.

30. Brewer JD, Wee A, Seghi R. Advances in color matching. Dent Clin North Am. 2004; 48: 341-358.

31. Schwabacher WB, Goodkind RJ, Lua MJR. Interdependence of the hue, value, and chroma in the middle site of anterior human teeth. J Prosthod. 1994; 3: 188-192.

32. O'Brien WJ, Hemmendinger H, Boenke KM, Linger JB, Groh CL. Color distribution of three regions of extracted human teeth. Dent Mater. 1997; 13: 179-185.

33. Alshiddi IF, Richards LC. A comparison of conventional visual and spectrophotometric shade taking by trained and untrained dental students. Aust Dent J. 2015; 60: 176-181.

34. Jain M, Jain V, Yadav NR, Jain S, Singh S, Raghav P et al. Dental students' tooth shade selection ability in relation to years of dental education. Family Med Prim Care. 2019; 8: 4010-4014.

35. Jaju RA, Nagai S, Karimbux N, Da Silva JD. Evaluating tooth color matching ability of dental students. J Dent Educ. 2010; 9: 1002-1010.

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