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THE TOOTH SHADE MATCHING ABILITY AMONG DENTAL PROFESSIONALS: A COMPARATIVE STUDY

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ABSTRACT

Background: **Shade matching presents a complex and multidimensional process that involves the cognitive ability of the operator. Hence, dental professionals need to have high shade matching skill.**

Objective: **To compare the shade matching ability among three categories of dental professionals and assess the inter-examiner reliability of the visual shade selection.**

Method: **This was a cross sectional study involving conventional visual tooth shade selection by three categories of dental professionals. Twenty four patients that met the selection criteria were included in the study and Ethical approval duly obtained. Visual shade selection using vital classical shade guide was done by calibrated 3 categories of the dental professionals. Data collected was analysed using IBM SPSS with statistical significance placed at $p \leq 0.05$**

Results: **There were 9 (37.5%) male and 15 (62.5%) female participants with mean age ±SD of 39.9 ± 18.47 years. In the shade selection, the dental surgery technician and the house officer agreed in 2 (7.7%) teeth, dental surgery technician and consultant in 6 (23.1%) teeth while the house officer and consultant did so for 8 (30.8%) teeth. The three examiners agreed on shades selected for only 1 (3.8%) tooth. Inter-examiner reliability was 0.11. Shades selected by the consultant matched that of the spectrophotometer in 3 of the 26 teeth (11.5%) being the best.**

Conclusion: **Inter-examiner reliability was very low in the conventional visual shade selection. Experience and training in colour science and shade selection may play a role in correct tooth shade selection.**

Keywords: Shade selection, Shade guide, Dental professionals

INTRODUCTION

Perception of colour which is a complex phenomenon is considered an important part of aesthetic dentistry and an essential goal for a dentist who wants to choose toothshade correctly to meet the demands of patients for satisfactory restorations.[1,2] Any slight change in the colour of a restoration may lead to a significant cosmetic problem and makes the prosthesis look artificial and unacceptable to the patient.[3,4] Perception depends on the three entities namely the light source, the object and the detector (human eye).[5] Despite the fairly high knowledge of proper shade selection procedures among the dental practitioners[6] understanding the colour and appearance of teeth is a difficult task. There are many factors such as lighting conditions, translucency, opacity, light scattering, surface texture, gloss with the human eye and brain influencing the overall perceptibility and acceptability of tooth colour. The very first step to achieving good clinical outcome in aesthetic dentistry is the ability to correctly identify the tooth colour we need to imitate and the material that most closely matches it, as well as, the correct, conveyance of this information to the laboratory.[7]

However, there are many challenges that the clinicians face, which makes it difficult in selecting the correct tooth shade and influence the outcome of tooth-coloured extra-coronal restorations.[5] One of such factors is metamerism in which an object present with different colour when viewed under different conditions such as light source, instruments, geometric angle to mention a few. The perceived colour of a tooth is affected by its reflecting ability which in turn is influenced by the source of light.[8-9] More so, the translucency of enamel and the polychromatic nature of dentine together produce complex depth of shade that is not easy to characterize.[10] Consequently, the distribution of shade guides on the Commission Internationale de l'Eclairage (CIELAB) colour space is not uniform, hence, the entire range of natural tooth shade is not covered.[11] Fatigue, personality, gender and colour defects are other human physiological factors

that affect visual tooth matching.[12] Tooth colour measurement can either be done subjectively by the operator through the use of shade guides, or objectively by placing a device which technologically performs the role of an observer while eliminating the effect of negative visual illusion, to deliver exact and reproducible information.[13] One of such devices is spectrophotometer.

Spectrophotometer is a sophisticated device that has several configurations which measures the spectral reflectance of an object. It is a form of photometer for measuring light intensity, it tends to measure the wave length as a function of the colour.[14] A spectrophotometer possesses a white light source either a tungsten-filament bulb or LED lamp which create a light output of wavelength between 400 and 700 nm. The light passes through a prism and emerges into a spectrum of wavelength bands between 10 and 20 nm, gets to the object, which may reflect, pass, or scatter, as the object selectively absorbs the different wavelengths of light in varying amounts. The volume of light emitted from or transmitted through the object is measured for each wavelength band in the visible spectrum. The detector converts the intensity of the light at a particular wavelength into an electrical signal that is amplified and displayed on the screen of the device. These measurements are usually converted to a corresponding shade tab on shade guide. However, there are newer form of spectrophotometer that has monochromators and photodiodes that can measure the reflectance curve of an object's colour every 10 nm or even less.[15] Based on measurement geometry Spectrophotometer can be classified into two types namely: entire tooth surface measurement and spot measurement while showing some differences in the angle of irradiance/reflection, lighting sensors, and filters.[16]

Over the years, the traditional way of selecting tooth shade has been through visual observation by the unaided eye.[12,13] This is done by the operator visually comparing the tooth colour with standard shade guides (tabs of several hues and chroma) and choosing the one he/she perceives to be the best or closest match.[14,15]

The most common system for visual selection of tooth colour is the Munsell colour system; the parameters used are the triads of value, chroma and hue. Value (lightness) is determined first by selecting a tab that closely matches the lightness or darkness of the colour, which spans between white and black.[16] Next to be obtained is the chroma with tabs that are close to the measured value but are of increasing intensity of colour. Chroma ranges from achromatic or grey to a highly saturated colour. Hue is obtained last by matching with colour tabs of the "value" and "chroma" already determined. Hue is measured on a scale of 2.5 to 10 in increments of 2.5 for each of the 10 colour families (red, R; yellow-red, YR; yellow, Y; green-yellow, GY; green, G; blue-green, BG; blue, B; purple-blue, PB; purple, P; red-purple, RP).[17]

Tooth colour matching is most commonly performed visually using dental shade guides also known as colour standards, which is a tab of different hues that serves to determine a tooth shade accurately. To avoid the problems of metamerism these shades guide are made of porcelain materials.[17] Different types of colour standards (shade guides) are used in dentistry, depending on their purpose and the tissue for which they are intended. These include tooth shade guides, shade guides for oral soft-tissues and shade guides for facial prostheses commonly known as dental, gingival and facial shade guides, respectively. The first shade guide was introduced by Vita Zahnfabrik in 1956.[4] Thereafter, various shade guides have been introduced which include VITA classic shade guide, Chromascope, Hayashi shade guide, Clark shade guide, Vitapan 3D-Master shade guide, Spectatone amongst others. VITA classical shade guide is the most popular and one of the most commonly used shade guide. It consists of 16 tabs that are arranged into four groups according to the hue.[4]

Studies have found that human eye is capable of detecting even small differences, while other authors have mentioned that the human evaluation of tooth shade is unreliable.[18] Traditional visual tooth shade selection is characterized by high intra-examiner variability and unpredictability, due to the numerous subjective factors that affect colour selection.[19] The consistency and reliability of visual shade matching are therefore questionable. The perception of colour difference seems to be learned trait although the personality of the patient can also have influence on this. Therefore, this present study focused on comparing the shade matching skill amongst the dental professionals, and assesses the inter-examiner reliability of the visual shade selection. Furthermore, the shade selected subjectively by the professionals were compared with spectrophotometer; an objective form of shade assessment.

MATERIALS AND METHOD

This was designed as a cross sectional study involving conventional visual tooth shade selection. Twenty four patients with 26 teeth that presented for porcelain fused to metal crown fabrication of anterior teeth and premolars were included in the study using convenient sampling. Patient with teeth discoloration and those that have had orthodontic treatment done were

excluded from the study. Ethical approval was obtained from the ethical committee of the University College Hospital/University of Ibadan with ethical number UI/EC/17/0507. Patients were asked to undergo scaling and polishing a week before the shade selection procedure was done to remove any extrinsic stain. Also, patients brushed for one minute just before the shade selection to remove any accumulated plaque. Visual shade selection was done for each patient using

VITA classical shade guide by three categories of dental professionals; a specialist restorative dentist (consultant), a dental surgery intern (house officer) and a dental surgery technician (dental nurse). The online Ishihara's colour chart test was used to test the examiners and patients for colour vision prior to the shade selection to rule out any visual defect that could affect the outcome of the colour matching. The examiners were calibrated before the commencement of the shade matching. Shade was matched under a daylight colour-corrected light device (Corrected dental light, Bremadent Premier (Bristol) LTD, Walthanshn, London E177PJ) with correlated colour temperature of 5500k.

Shade selection was carried out by each examiner at separate times. Patient was positioned upright on the dental chair with the head firmly positioned in the headrest. Coloured eye glasses were removed as well as coloured make up (such as lipstick) in female patients and patient's cloth was covered with grey bib. The examiner positioned him/herself at a distance of about 28 to 33cm from the patient while taking the shade. The comparison of tooth colour with shade tabs was not viewed for more than 7 seconds each time to avoid fatigue.[21] Shade of the middle third of tooth was taken with the teeth well hydrated using a jet of clean water. The shade guide was moistened with water to mimic the tooth that is constantly bathed with saliva in the mouth and was thoroughly disinfected with methylated spirit after each shade selection in each patient. Shade guide tab labels were covered and assigned three digit ID numbers (code) by the primary investigator, with the code clearly written on it. The order in which the target shade tabs were arranged was randomized for each shade matching session. The examiners recorded the code for whatever shade they selected, this was to blind the examiners and prevent them from guessing the shade based on the pre-knowledge of the shade commonly selected for a particular tooth. Shade guide teeth were placed close to the tooth to be matched, above or below it (not by the side to avoid binocular effect). Each examiner recorded the shade (i.e. the coded number) he or she selected on a piece of paper and placed it in an envelope next to the operatory chair. The investigator collected the envelopes after all examiners had finished shade matching. Any two or three identical shade selected by the examiners was taken as the final shade selected. When none of the three shades for the three examiners was identical, the patient was asked to pick the shade he/she felt was the best match out of the three shades, and that was used as the final shade for the restoration fabrication. Shade selection was also done by the investigator using Vita easyshade advance V spectrophotometer (Vasa Denticity Private Limited. Ghitorni, Delhi, India) that was calibrated according to the manufacturer specification. The shades selected by visual and instrumental method were recorded.

Data were entered into personal computer spread sheet and analysis was done using IBM SPSS Statistics for Windows, Version 23.0. Armonk, NY: IBM Corp. Normalcy of the data was assessed using Kolmogorov -Smirnov test and found to be normally distributed. Descriptive statistics including frequency, mean and standard deviation were used to report parameters for each method of shade selection analysed in the study. Inter-examiner reliability was measured using Cohen's Kappa coefficient. Statistical significance was placed at $p \leq 0.05$

RESULT

Nine (37.5%) males and 15 (62.5%) females participated in the study (Figure 1). The mean age ±SD of the participants was 39.9 ± 18.47 years. The dental surgery technician and the house officer agreed on shades selected in 2 (7.7%) teeth out of the 26 teeth. The dental surgery technician and consultant selected the same shade for 6 (23.1%) teeth while the house officer and consultant did so for 8 (30.8%) teeth. The three examiners agreed on shades selected for only 1 (3.8%) tooth. While in eleven (11) (42.3%) cases, all the three visual selections differed. Inter-examiner reliability measured with Cohen's Kappa coefficient was 0.11 (Table 1)

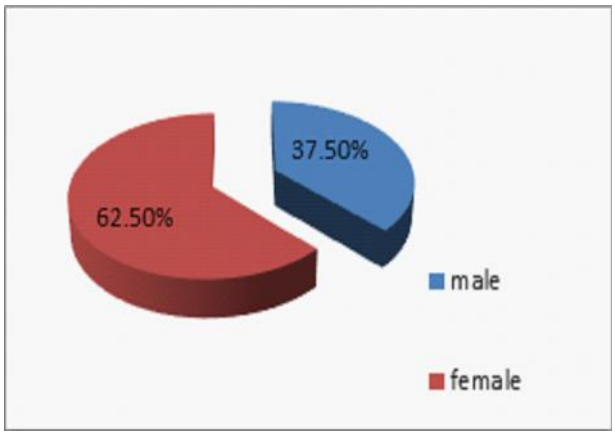

Figure1: Gender distribution of participants

Table 1: Distribution of tooth shades selected by three examiners using conventional visual method (Vita shade guide)

Participants Serial number	Examiners Shade selected by Dental surgery technician	Shade selected by House officer	Shade selected by Consultant	Final shade
1	**A1**	B1	**A1**	A1
2	D2	B1	C2	C2
3	B1	**A1**	**A1**	A1
4	D2	**A2**	**A2**	A2
5	**D3**	A3	**D3**	D3
6	D3	A2	B2	B2
7*	**B1**	**B1**	**B1**	**B1**
8	C1	**D2**	**D2**	D2
9	B2	A2	D4	D4
10	**A2**	C2	**A2**	A2
11	A2	**B2**	**B2**	B2
12	C1	**B2**	**B2**	B2
13	A3.5	B3	D4	A3.5
14	B3	D4	C4	D4
15	D2	C1	A1	D2
16	A2	C2	A3.5	A2
17	**A1**	D2	**A1**	A1
18	A2	**B3**	**B3**	B3
19	A2	A3	D3	A3
20	A2	D3	B2	A2
21	A3	**D4**	**D4**	D4
22	A1	A2	C1	C1
23	**D4**	**D4**	B3	D4
24	D3	A3.5	A3	A3
25	**A1**	B1	**A1**	A1
26	A2	A1	B2	A2

**Shaded row= same tooth shade selected by the three examiners (3.8%)*
Inter-examiner reliability measured with Cohen's Kappa coefficient = 0.11

Table 2: Final tooth shades selected using conventional visual and spectrophotometric methods

Participants	Conventional visual method	Spectrophotometric method
1	A1	D3
2	C2	C4
3	A1	A2
4	A2	C2
5	D3	C3
6	B2	C4
7	B1	C3
8	D2	A4
9	D4	C3
10*	A2	A2
11	B2	A3
12	B2	A3.5
13	A3.5	C4
14	D4	C4
15	D2	B2
16	A2	B3
17	A1	A2
18	B3	A4
19	A3	C4
20	A2	B2
21	D4	A3.5
22	C1	C3
23	D4	A4
24	A3	B4
25	A1	A3
26	A2	A3

**Shaded row= same tooth shade selected by both methods in only 1 case (3.8%)*

Table 3: Comparison of shade selected by each examiner with the final shade selected. Using spectrophotometer

Participants	Tooth shades selected by the three examiners and the spectrophotometer			
Serial number	Dental surgery technician	House officer	Consultant	Spectrophotometer
1	A1	B1	A1	D3
2	D2	B1	C2	C4
3	B1	A1	A1	A2
4	D2	A2	A2	C2
5	D3	A3	D3	C3
6	D3	A2	B2	C4
7	B1	B1	B1	C3
8	C1	D2	D2	A4
9	B2	A2	D4	C3
10*	**A2**	C2	**A2**	**A2**
11	A2	B2	B2	A3
12	C1	B2	B2	A3.5
13	A3.5	B3	D4	C4
14*	B3	D4	**C4**	C4
15	D2	C1	A1	B2
16	A2	C2	A3.5	B3
17	A1	D2	A1	A2
18	A2	B3	B3	A4
19	A2	A3	D3	C4
20*	A2	D3	**B2**	B2
21	A3	D4	D4	A3.5
22	A1	A2	C1	C3
23	D4	D4	B3	A4
24	D3	A3.5	A3	B4
25	A1	B1	A1	A3
26	A2	A1	B2	A3

**Shaded row: same shade selected by examiner and spectrophotometer*

In the final toothshade selection process, among the 26 teeth, only one (3.8%) had the same shade selected using both the conventional visual and spectrophotometric shade methods. This indicates poor agreement between the two methods of shade selection (Table 2). Shades selected by the consultant matched that of the spectrophotometer in 3 of the 26 teeth (11.5%) being the best. The dental surgery technician matched in only 1 (3.8%), while shades selected by the house officer did not agree with that of the spectrophotometer in any of the teeth. (Table 3)

DISCUSSION

Shade guides remain the most popular options for tooth colour selection despite the recent advances in shade matching instruments to reduce variability.[20] One of the most important factors in the determination of tooth colour is a clinician's colour perception.[21] Even for a dentist with colour vision, matching of tooth shade is complicated by the individual's own differences in colour observation.[20]

This study found a very low (3.8%) inter-examiner agreement in shade selection by the 3 examiners. The inter-examiner reliability measured with Cohen's Kappa coefficient was 0.11. This very low inter-examiner agreement may be due to the disparity in experience and training of the three examiners in the study. This is however, different from the results of study by Paul *et al.*,[22] in which the three examiners using visual shade selections matched in 8 of the 30 patients (26.6%). Similarly, Gehrke *et al.*,[23] in their own study of 40 cases reported that all the three human examiners obtained the same shade in 22.5% of the cases. Furthermore, Paul *et al.*,[24] reported that 2 out of 10 (20%) cases of shade evaluated in all three visual shade selection matched. Individual differences and personality of the evaluators of visual shade selection in the various studies may account for the variation in the results. These results, nevertheless, pointed to the fact that visual shade selection is highly subjective and not very reliable.

Comparing the shade selected by each of the three examiners using the conventional visual method with

the final shade selected by the use of spectrophotometer, it was observed that the level of agreement between the shade selected by the three examiners using conventional method and the spectrophotometer was generally low. This was similar to that of Meireles *et al.*,[25] who in their study found that the agreement between visual assessment by the examiners and digital spectrophotometer was also low. On the contrary, Guan *et al.*,[26] using extracted teeth observed a positive correlation between the digital spectrophotometer and visual assessment methods of tooth colour. This difference may be attributed to condition of the tested extracted teeth (in vitro) which was different from the teeth used in the current study (in vivo) which were in their normal physiological environment. However, the consultant had higher agreement of 11.5% followed by the dental surgery technician with 3.8% match while the shade selected by the house officer did not match that of spectrophotometer in any of the cases. The higher percentage by the dental surgery technician when compared with the house officer may be as a result of length of years of experience in the clinical practice. This finding was in variant with the study of Moodley *et al.*,[27] that reported a better agreement of the shade selected by the 2 operators in their study with that of spectrophotometer.

In colour science, the influence of the level of experience and professional training is controversial; some authors have reported positive effects while others see no significant differences.[28,29,30,31] This current study found that the house officer and the consultant tended to select more same shade than the dental technician. However, the shade selected by the house officer did not match any of the spectrophotometer. This may be as a result of experience coupled with the kind of training the dentists had received on shade selection in school at one point or the other. Della *et al.*,[28] reported that there was correlation between visual-instrument agreement and the experience of the operators. This finding was further supported by some studies[32,33,34,35], that emphasised the fact that training in colour and experience have impact on the shade matching ability. Furthermore, Alshiddi *et al.*,[29] reported that trained students were able to assess tooth shade better than untrained students. Pimentel and Tiossi[30] also reported that a successful tooth shade selection relies on adequate knowledge of colour science and control of the variables that influence the visual colour assessment. Contrarily, Udijak *et al.*,[31] claimed there is no role of previous knowledge and experience in dental shade matching.

CONCLUSION

1. Within the limitation of this study, it was found that Inter-examiner reliability was very low in the conventional visual shade selection. However, experience and training in colour science and shade selection may play a role in correct tooth shade selection.
2. There is need to lay emphasis on training in colour science at undergraduate level

REFERENCE

1. **Sulaiman AO,** Adebayo GE. Most frequently selected shade for advance restoration delivered in a Tertiary Hospital facility in South Western Nigeria. Ann Ibd Pg Med. 2019;17:157–161.
2. **Enone L,** Oyapero A, Makanjuola J. Perception and practices with regard to tooth shade selection for composite restoration among dentists in Southwest, Nigeria. Indian J Dent. 2020;12:80-86.
3. **Douglas RD,** Steinhauer TJ. Intraoral determination of the tolerance of dentists for perceptibility and acceptability of shade mismatch. J Prosthet Dent. 2007;97(4):200–208.
4. **Chu SJ,** Devigus A, Mieleszko A. Fundamentals of colour shade matching and communication in aesthetic Dentistry. Second edition. Quintessence Publ co inc. 2004;
5. **Touati B.** Excellence with simplicity in aesthetic dentistry. Pr Periodontics Aesthet Dent. 1997;9(7): 806–808.
6. **Sulaiman AO,** Adebayo GE, Egbe TA. Evaluation of knowledge and technique of shade selection among Nigerian dentists: a pilot study. Afr J Med Med Sci. 2020;49:89–94.
7. **Xiao J,** Zhou X, Zhu W, Zhang B, Li J, Li J. The prevalence of tooth discolouration and the self-satisfaction with tooth colour in a Chinese urban population. J Oral Rehabil. 2007;34(5):351–360.
8. **Corcodel N,** Rammelsberg O, Moldovan J, Dreyhaupt A. Effect of external light conditions during matching of tooth color: an intra-individual comparison. Int J Prosthodont. 2009;22(1):75–77.
9. **Villarroel M,** Fahl N, De Sousa A. Direct aesthetic restorations based on translucency and opacity of composite resins. J Esthet Restor Dent. 2011;23(2):73–87.
10. **Hasegawa A,** Ikeda I, Kawaguchi S. Colour and translucency of in vivo natural central incisors. J Prosthet Dent. 2000;83(4):418–423.
11. **Bayindir F,** Kuo S, Johnston W, Wee A. Coverage error of three conceptually different shade guide systems to vital unrestored dentition. J Prosthet Dent. 2009;98(3):175–185.
12. **Jaint N,** Verma P, Mittal S, Singh A, Munjal S. Gender based alteration in color perception. Indian J Physiol Pharmacol. 2010;54(4):366–370.
13. **Gómez-Polo C,** Gómez-Polo M, Celemin-Viñuela A, Martinez JA. Differences between the

human eye and the spectrophotometer in the shade matching of tooth. J Dent. 2014;42(6):742–745.
14. **Weitz C,** Miyake Y, Shinzato K, *et al.* Human tritanopia associated with two amino acid substitutions in the blue-sensitive opsin. Am J Hum Genet. 1992;50(3):498–507.
15. **Analoui M,** Papkosta E, Cochran M, Matis B. Designing visually optimal shade guide. J prosthet Den. 2004; 92:371–376.
16. **Farhad T,** Elaheh B, Parisa A, Saied E. Visual and digital tooth shade selection methods, related effective factors and conditions, and their accuracy and precision: A literature review. J Esthet Restor Dent. 2021;1–21.
17. **Agrawal V,** Kapoor S. Color and shade management in aesthetic dentistry. Univers Res J Dent. 2013;3(3):120–127.
18. **Browning WD,** Chan DC. A Comparison of human raters and an intra-oral spectrophotometer. Operative Dentistry 2009;34(2):337–343.
19. **Raghunathan J,** Ramesh A, Prabhu K, Gayathri R. A systematic review of efficacy of shade matching in prosthodontics. Int J Recent Sci Res. 2016;7(4):9949–9954.
20. **Jain M,** Jain V, Sharma A. Dental students' tooth shade selection ability in relation to years of dental Education. J Family Med Prim Care. 2019;8:4010-4014
21. **Chu SJ.** Clinical steps to predictable color management in aesthetic restorative dentistry. Dent Clin North Am. 2007;51:473–485.
22. **Paul S,** Peter A, Pietrobon N, Hammerle C. Visual and spectrophotometric shade analysis of human teeth. J Dent Res. 2002;81:578–582.
23. **Gehrke P.** Comparison of In vivo visual, spectrophoto-metric and colorimetric shade determination of teeth and implant-supported crowns. Int J Comput Dent. 2009;12(000):1–17.
24. **Paul S,** Peter A, Rodoni L, Pietrobon N. Conventional visual vs spectrophotometric shade taking for porcelain-fused-to-metal crowns: a clinical comparison. Int J Perio Res Dent. 2004; 24(3):222–231.
25. **Meireles SS,** Demarco FF, Santos IS. validation and reliability of visual assessment with a shade guide for tooth-color classification. 2008;121–126.
26. **Guan Y,** Lath D, Lilley T, *et al.* The measurement of tooth whiteness by image analysis and spectrophotometry: a comparison. J Oral Rehabil. 2005;(32):7–15.
27. **Moodley T,** Patel N, Ranchod H. Comparison of colour differences in visual versus spectrophotometric shade matching. South African Dent J. 2015;70(9):402–407.
28. **Della B,** Barrett A, Rosa V, Pinzetta C. Visual and instrumental agreement in dental shade selection: three distinct observer populations and shade matching protocols. Dent Mater. 2009;25 (2):276–281.
29. **Alshiddi I,** Richard L. Comparison of conventional visual and spectrophotometric shade taking by trained and untrained dental students. Aust Dent. 2015;60:176–181.
30. **Pimental W,** Tiossi R. Comparison between visual and instrumental methods for natural tooth shade matching. Gen Dent. 2015;62(6):47-49
31. **Udijak Z,** Illes D, Knezovic D, Celic R. Effect of clinical experience on the shade matching accuracy in different dental occupational groups. Acta Stomatol croat. 2018;52(2):132–139.
32. **Capa N,** Malkondu O, Kazazoglu E, Calikkocaoglu S. Evaluating factors that affect the shade-matching ability of dentists, dental staff members and laypeople. J Am Dent Assoc. 2010;141(1):71–76.
33. **Llena C,** Forner L, Ferrari M, Amengual J, Llambes G, Esther L. Toothguide Training Box for dental colour choice training. J Dent Educ. 2011;75(3):360–364.
34. **Sinmazisik G,** Trakyali G, Tarcin B. Evaluating the ability of dental technician students and graduate dentists to match tooth colour. J Prosthet Dent. 2014;112:1559–1566.
35. **Xu M,** Xu T, Liu F, Shi X, Feng H. The influence of toothguide training box on shade matching veracity. Shangai J Stomatol. 2009;18:432–435.