





## Investigation of Color Selection Criteria Determined by Dentists in Different Titles and Study Centers

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### Abstract

**Background:** Color selection holds significant importance in the field of dentistry, particularly concerning aesthetics and achieving a natural appearance. However, diverse dentists and practice centers may adopt distinct methodologies in their color selection processes. This study aims to investigate the criteria guiding color selection in prosthetic treatments among dentists with varying titles in different workplace settings.

**Material and Methods:** Approval for this study was obtained from the Clinical Research Ethics Committee of Dicle University Faculty of Dentistry (2019/44). Conducted in September 2019, the study involved a voluntary survey distributed among academics and dentists nationwide. The survey comprised 14 questions, two collecting demographic data and the remaining 12 presenting multiple-choice inquiries.

**Results:** A total of 437 participants, consisting of 213 males and 224 females, completed the study. The average age of participants was 30.6, with 50.6% working in university hospitals. Other participants were distributed among oral and dental health centers, community health centers, state hospitals, private clinics owned by themselves, or private clinics owned by another dentist. In terms of professional roles, 43.7% identified as general practitioners, 27.7% as dental students, 17.8% as research assistants, 7.8% as specialist dentists, and 3% as faculty members. SPSS 22 (Statistical Package for the Sciences Version 22.0) was employed for data analysis, utilizing the chi-square test for categorical data. Statistical analysis was conducted with significance set at  $p < 0.05$ .

**Conclusion:** This study reveals a lack of standardized approaches among dentists in the color selection process for prosthetic dental treatments. Given the rising expectations in aesthetics, it is advocated that a standardized protocol be established to ensure accurate color determination and enhance the overall success of treatments.

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**Key words:** Color selection, aesthetics, standardization.

### Introduction

Prosthetic treatments hold a pivotal role in addressing diverse dental issues, encompassing the rectification of tooth deficiencies, aesthetic enhancements, and the restoration of oral functionalities. The triumph of such treatments is contingent upon the meticulous selection of an appropriate color to attain a natural and harmonious aesthetic. The chosen color must seamlessly integrate with the adjacent tissues of the patient's teeth and complement the overall oral structure. Aesthetic components, namely the general configuration of dental restoration, its surface structure, light transmittance, and the color of the utilized materials,

constitute fundamental elements governing the overall aesthetic appeal. Consequently, the process of color determination emerges as a critical juncture significantly impacting the aesthetic success of the restoration. However, the complexity of the color selection process often leads to variations in approaches among dentists (1,2,3).

Numerous factors wield influence over the identification of the optimal tooth color. Various tools and techniques, including visual inspection, employment of color scales, color analysis devices, consideration of patient preferences, color testing, assurance of color stability, and consultation with different specialist physicians, can be employed (4).

To visually assess the current tooth and gum color of the patient and ensure harmony, it becomes imperative to employ light sources that closely mimic both natural and artificial lighting conditions affecting color perception. The utilization of color scales and validation through digital color analyzers is necessary to pinpoint the most fitting tone amid different options. Naturally, the integration of appropriate colors aligned with patient expectations, coupled with the insights of diverse medical professionals, is integral to the process (5,6).

The objective of this study is to scrutinize the methodologies employed in determining color selection criteria within diverse dental practice centers where dentists of varying titles operate. This investigation stands as a significant stride toward comprehending the existing diversity and distinct approaches to color selection in prosthetic treatments. The gleaned insights aim to serve as a compass for refining the color selection process in prosthetic treatments, fostering more standardized and reliable outcomes.

### Material and Method

This research adopts a survey-based design, comprising a total of 14 questions. Two of these questions pertain to demographic information, while the remaining 12 are optional inquiries. The study actively encourages voluntary participation from academics and dentists nationwide.

### Ethical Approval:

Ethical considerations were meticulously observed throughout the study. Approval for the research protocol was obtained from the Dicle University Faculty of Dentistry Clinical Research Ethics Committee under the reference number 2019/44, signifying adherence to ethical standards in human research.

### Participant Selection Criteria:

The inclusion criteria for participants stipulated active engagement in patient care and a willingness to partake in the study. Only dentists meeting these criteria were considered eligible for inclusion.

### Inclusion Criteria:

To be eligible for participation, individuals must hold the title of dentist and actively engage in patient care.

### Exclusion Criteria:

Physicians who declined participation, those not currently practicing the dental profession or involved in patient care, were excluded from the study.

### Recruitment and Consent:

Participants were recruited on a voluntary basis, emphasizing their professional involvement in patient care. Prior to inclusion, informed consent was obtained from each participant, affirming their willingness to contribute to the study.

### Research Initiation:

Following the approval report (2019/44) from the Dicle University Faculty of Dentistry Clinical Research Ethics Committee, the research commenced in accordance with the established ethical framework. This stringent adherence to inclusion and exclusion criteria, along with ethical considerations, ensures the reliability and integrity of the study's methodology.

### Results

The comprehensive study involved 437 participants, comprising 213 males and 224 females, with an average age of 30.6. Among them, 50.6% were affiliated with university hospitals, while others served in various capacities in oral and dental health hospitals, community health centers, public hospitals, or private clinics. The distribution of professional roles indicated that 43.7% were general practitioners, 27.7% were dentistry students, 17.8% were research assistants, 7.8% were specialist physicians, and 3% held lecturer positions.

**Table I:** Survey Form Applied to Volunteer Physicians

<b>General Information</b>	Your age: ( ) years Your gender: Female ( ) Male ( ) Years of professional experience: ( ) years
<b>Where do you practice your profession?</b>	<input type="checkbox"/> in your own private clinic <input type="checkbox"/> in someone else's private clinic <input type="checkbox"/> in a university hospital <input type="checkbox"/> in a public hospital or state hospital
<b>What is your professional title?</b>	<input type="checkbox"/> General Practitioner <input type="checkbox"/> Research Assistant Department: (.....) <input type="checkbox"/> Specialist Department: (.....) PhD ( ) Master's ( ) <input type="checkbox"/> Faculty Member Department: (.....)
<b>Which method do you use for color selection?</b>	<input type="checkbox"/> Visual Method - Color Scale (If your answer is this, go to Question 4; Otherwise, mark the method you use from the options below and proceed to Question 5.) <input type="checkbox"/> Color Determination Devices (Spectrophotometer, Digital Color Measurement Device, Colorimeter) <input type="checkbox"/> Program Commonly Used with the Laboratory <input type="checkbox"/> Photography
<b>Which color scale do you use when choosing colors?</b>	<input type="checkbox"/> Ivoclar Classic Color Scale <input type="checkbox"/> Vita Classic Color Scale <input type="checkbox"/> Vita 3D Master
<b>Do you have hereditary or acquired color blindness?</b>	<input type="checkbox"/> Yes, (Proceed to Question 6) <input type="checkbox"/> No, (Proceed to Question 7)
<b>Do you seek assistance from another set of eyes when choosing colors in your dental treatments?</b>	<input type="checkbox"/> Yes, I take <input type="checkbox"/> No, I don't take
<b>what type of lighting do you use in your workspace when selecting colors?</b>	<input type="checkbox"/> Only Daylight <input type="checkbox"/> Daylight + Fluorescent Light <input type="checkbox"/> Only Fluorescent Light <input type="checkbox"/> Daylight + Reflector Light + Fluorescent Light <input type="checkbox"/> Daylight + Reflector Light <input type="checkbox"/> Reflector Light + Fluorescent Light
<b>How many seconds does it take for you to determine the color of prosthetic restorations?</b>	<input type="checkbox"/> 0-5 seconds <input type="checkbox"/> 5-10 seconds <input type="checkbox"/> >10 seconds
<b>When selecting colors, do you:</b>	<input type="checkbox"/> I seat the patient in the chair. <input type="checkbox"/> The patient is standing; there is a height difference between the dentist and the patient. <input type="checkbox"/> The patient is standing; there is no height difference between the dentist and the patient.
<b>Perform a polishing procedure on the teeth before choosing the color?</b>	<input type="checkbox"/> Yes <input type="checkbox"/> No
<b>Take photographs of the patient before selecting the color and send records to</b>	<input type="checkbox"/> Yes <input type="checkbox"/> No

the laboratory?

**Survey Result Distributions:**

**Table II:** General Information of Survey Respondents

	<b>%(n) veya mean±SD</b>
<b>Gender</b>	
Male	48.7(213)
Female	51.3(224)
<b>Age</b>	30.6±9.7
<b>Where do you practice your profession?</b>	
University hospital	50.6 (221)
ADSM-TSM-State hospital	26.1 (114)
Private clinic owned by yourself	15.6 (68)
Private clinic owned by another dentist	7.8 (34)
<b>Professional title</b>	
General practitioner	43.7 (188)
Dentistry student	27.7 (121)
Research assistant	17.8 (77)
Specialist dentist	7.8 (34)
Faculty member	3 (16)

**Table III:** Effects of Gender on Color Selection

**Effects of Gender on Color Selection**

	<b>Gender</b>		p
	<b>Male (n:213)</b>	<b>Female (n:224)</b>	
<b>What type of lighting do you use in your workspace when selecting color?</b>			0.06
Daylight+reflector+fluorescent	%7.5(16)	%5.8(13)	
Daylight+fluorescent	%23(49)	%16(36)	
Daylight+reflector	%5.2(11)	%6.7(15)	
Reflector+fluorescent	0	%1.3(3)	
Only fluorescent	%1.4(3)	0	
Only daylight	%62.9(134)	%70(157)	
<b>Patient positioning</b>			0.59
Patient mouth-Doctor eye at the same level, sitting upright	%62.4(133)	%67(150)	
Patient mouth-Doctor eye at the same level, sitting inclined	%11.3(24)	%9.4(21)	
Patient eye-Doctor eye at the same level, sitting upright	%26.3(56)	%23.4 (53)	
<b>Determining the color of prosthetic restoration</b>			0.9
0-5 seconds	%28(60)	%29(65)	
5-10 seconds	%38.5(82)	%31(71)	
>10 seconds	%33(71)	%39(88)	

**Testing the compatibility of the final color of the prosthesis with the pre-determined color**

0.19

Yes	%86.4(184)	%81.7(183)
No	%13.6(29)	%18.3(41)

Statistical analysis revealed no significant difference between genders concerning the type of light used in the working environment, patient

positioning, color determination time, and testing whether the final color of the prosthesis matched the predetermined color.

**Table IV: Effects of Age on Color Selection****The Effects of Age on Color Selection**

	Age			p
	>30 Age	30-50 Age	50<	
<b>What type of lighting do you use in your workspace when selecting color?</b>				<0.01
Daylight+reflector+fluorescent	%6.6(19)	%7.8(9)		
Daylight+fluorescent	%3(1)			
Daylight+reflector	%18(52)	%23.5(27)		
Reflector+fluorescent	%18(6)			
Only fluorescent	%5.2(15)	%7(8)		
Only daylight	%9(3)			
	%1(3)	0	0	
	%0.7(2)	0		
	%3(1)			
	%68.5(198)	%61.7(71)		
	%66.7(22)			
<b>Patient positioning</b>				0.9
Patient mouth-Doctor eye at the same level, sitting upright	%67.1(194)	%58.3(67)		
Patient mouth-Doctor eye at the same level, sitting inclined	%66(22)			
Patient eye-Doctor eye at the same level, sitting upright	%8.3(24)	%14.8(17)	%12(4)	
	%24.6(71)	%27(31)	%21(7)	
<b>Determining the color of prosthetic restoration</b>				0.7
0-5 seconds	%30(87)	%29(34)		
5-10 seconds	%12(4)			
>10 seconds	%40(116)	%38(44)		
	%30(10)			
	%30(86)	%32(37)		
	%57(19)			

Among participants under the age of 30, between the ages of 30-50, and over the age of 50, no statistical significance was found in the type of light used in the study environment and patient positioning. However, a

notable difference emerged among participants over 50, indicating that the color of the restoration was not determined within the first 5 seconds between age groups.

**Table V: Effects of Color Blindness on Color Selection**

## The Effects of Color Blindness on Color Selection

	Color blindness		p
	Yes(n:12)	No(n:425)	
<b>Determining the color of prosthetic restoration</b>			<0.01
0-5 seconds	%75(9)	%27(116)	
5-10 seconds	0	%40(170)	
>10 seconds	%25(3)	%33(139)	
<b>Which method do you use for color selection?</b>			0.9
Photography	%8(1)	%5.2(22)	
Visual method-color scale	%91(11)	%92.5(39)	
Any smile design program	0	3)	
Color determination devices	0	%0.2(1) %2.1(9)	
<b>Do you seek assistance from another pair of eyes when choosing the color in dental treatments?</b>			0.7
Yes	%83.3(10)	%73.2(31)	
No	%16.7(2)	1) %26.8(11) 4)	

For participants diagnosed with color blindness, 75% reported making color selections within 0-5 seconds, a statistically significant result. Notably, no significant difference was observed in color selection methods between individuals with and without a color blindness diagnosis. The visual method and color scale were identified as the most prevalent methods. Regarding seeking assistance from another individual when choosing colors in dental treatments, 83.3% of those with color blindness and 73.2% without a color blindness diagnosis affirmed receiving such assistance. The conclusion drawn was that the participants' diagnosis of color blindness did not significantly impact their ability to determine color with external assistance.

### Discussion

The role of color selection in prosthetic dental treatments is crucial, directly impacting the aesthetic outcome of restorations (6). A seamless integration of color with neighboring teeth is essential for the overall success of restorations. This study aims to assess the correlation between methods and criteria employed by dentists and dentistry students in color selection, a critical step for treatment success (7).

Color selection involves translating color perception into effective communication, categorized as visual and digital methods (8). Presently, the visual method is preferred for its practicality. In our study, participants were provided with visual color scale options, and 43.3% indicated the use of the Vita Classic color scale.

Efficiency in color selection is emphasized, recommending completion within 5 seconds to prevent cone cell fatigue (9). Surprisingly, only 28.6% of participants adhered to this recommended timeframe in our study.

Age-related changes impact color perception, making differentiation between yellow and white challenging. This tendency towards yellow-brown tones becomes more pronounced after the age of 50, with a decline in color determination ability after the age of 60 (10). Our findings support this information, indicating that participants over 50 had a color identification time longer than 5 seconds.

Strategic patient positioning and color determination techniques are essential, necessitating alignment of the patient's mouth with the clinician's eye level. The clinician, positioned between the light source and the patient, must prioritize brightness and make selections with eyes half-squinted (11,12). Swift

color selection within 5 seconds is reiterated to avoid cone cell fatigue. Our study revealed that only 28.5% of prosthetic restoration color determination occurred within 5 seconds.

Factors influencing color selection include object-dependent, observer-dependent, and light source-dependent factors. Observer-related factors encompass color blindness, age, fatigue, medications, inter-eye color perception differences, and individual variations in color perception. Color blindness, impacting physicians' success in color selection, was noted below 1% among physicians in our study.

The study delves into the dichotomy of visual and digital color selection methods, highlighting the prevalent use of visual methods (16,17). The visual method is not without drawbacks, such as potential insufficiencies in available color keys and variations in color detection under different conditions. Our study underscores the need for standardization in color determination to align with the CIE color system (18). Diversity in light source usage and its impact on color perception are explored, aligning with existing literature noting variability in color measurements based on factors such as sunlight angles and time of day (19,20,21).

The susceptibility of the human eye to various factors, including environmental conditions, tooth discoloration positioning, and professional experience, is acknowledged. Gender-based differences in color perception, with reported color blindness discrepancies between male and female dentists, are discussed. The study indicates a high rate of seeking assistance from another physician during color selection, especially from female dentists (21,22,23,24).

In conclusion, this discussion illuminates the multifaceted considerations in color selection for prosthetic dental treatments, underscoring the need for efficient, standardized practices that account for individual, environmental, and age-related factors to enhance overall treatment success.

## Conclusion

This research sheds light on the diverse methodologies employed by dentists in prosthetic dental treatments for color selection. The findings underscore the absence of a standardized approach, highlighting the necessity for a unified protocol to meet the rising aesthetic expectations in dental

restorations. The study emphasizes the age-related variations in color identification time and the limited impact of color blindness on the selection process. The prevalent use of visual methods, despite potential drawbacks, suggests their practicality in current dental practices. The identified areas for improvement, such as the limited adherence to the recommended timeframe, call for attention to enhance efficiency. The significance of strategic patient positioning and consideration of environmental factors, including light source diversity, further contributes to the complexity of color selection. The high rate of seeking assistance, especially among female dentists, emphasizes the collaborative nature of decision-making in color selection. Overall, this research provides valuable insights into the multifaceted aspects of color selection, urging the development of systematic and standardized approaches for improved treatment success and aesthetic outcomes in prosthetic dental procedures.

**ETHICS COMMITTEE APPROVAL:** Our study was approved by the Ethics Committee of Dicle University (2019/44).

**CONTRIBUTION RATES OF RESEARCHERS:**  
**HÇ** planned the study and administered the survey,  
**VE** planned the study and contributed to writing,  
**AIZ** contributed to the implementation of the survey and administered the study discussion,  
**EGB** contributed to the study design and statistics.

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## CONFLICT OF INTEREST

There is no conflict of interest in this study.

## References

1. Beneducci WP, Teixeira ML, & Pedrini H. Dental shade matching assisted by computer vision techniques. *Computer Methods in Biomechanics and Biomedical Engineering: Imaging & Visualization*, 2023; 11(4), 1378-1396.
2. Joiner A. Tooth colour: a review of the literature. *Journal of Dentistry*, 2004; 32, 3-12.
3. Abdulsamee N, & Nagi P. Contemporary Understanding of Colors in Aesthetic Dentistry: Review. *EC Dental Science*, 2020; 19(2), 1-18.
4. Ragain JC, & Johnston WM. Color acceptance of direct dental restorative materials by human observers. *Color Research & Application*, 2000; 25(4), 278-285.

5. Aktas E, Bakir S, Bakir EP, & Eratilla V. The effects of vital whitening agents on the surface properties of three different restoration materials. *Biomedical Research (0970-938X)*, 2020; 31(2).
6. Chu SJ, Trushkowsky RD, & Paravina RD. Dental color matching instruments and systems. Review of clinical and research aspects. *Journal of Dentistry*, 2010; 38, e2-e16.
7. Blatz MB, Chiche G, Bahat O, Roblee R, Coachman C, & Heymann HO. Evolution of aesthetic dentistry. *Journal of dental research*, 2019; 98(12), 1294-1304.
8. Müdüroğlu R, Kıvrak TÇ, & NALÇACI A. Renk Belirlenmesinde Kullanılan Yöntem ve Cihazlar. *Cumhuriyet Dental Journal*, 2018; 21(1), 61-69.
9. Keyif F, Uzun G, Altunsoy S. Diş Hekimliğinde Renk Seçimi. *Hacettepe Diş Hek. Fak. Dergisi*, 2009; 33(4), 52-58.
10. Susan A. Strenk, Lawrence M. Strenk, Jane F. Koretz. The mechanism of presbyopia. *Progress in Retinal and Eye Research*, 2005; 24(3), 379-393.
11. Lee YK, Bum-Soon L, Cheol-We K. Effect of surface conditions on the color of dental resin composites. *J Biomed Mater Res*, 2002; 63.5, 657-663.
12. Raszewski Z, Chojnacka K, & Mikulewicz M. Effects of Surface Preparation Methods on the Color Stability of 3D-Printed Dental Restorations. *Journal of Functional Biomaterials*, 2023; 14(5), 257.
13. Moser JB, Wozniak WT, Naleway CK, Ayer WA. Color vision in dentistry: A survey. *J Am Dent Assoc*, 1985; 110, 509-510.
14. Ngente Z, Jadav B, Aafaque S, Patil A, Govindarajulu R, Muthusamy P, ... & Nayyar AS. Prevalence of color vision anomalies among dental professionals. *Middle East African Journal of Ophthalmology*, 2021; 28(3), 169.
15. Suliman A, Al-Abdali, T, Taslimi M, & Abdo A. Prevalence of Color Vision Deficiency among Dental Practitioners and its Effect on Shade Matching Ability. *The Open Dentistry Journal*, 2020; 14(1).
16. Abu-Hossin S, Onbasi Y, Berger L, Troll F, Adler W, Wichmann M, & Matta RE. Comparison of digital and visual tooth shade selection. *Clinical and Experimental Dental Research*, 2023; 9(2), 368-374.
17. Morsy N, & Holiel AA. Color difference for shade determination with visual and instrumental methods: a systematic review and meta-analysis. *Systematic Reviews*, 2023; 12(1), 95.
18. Chu SJ, Devigus A, Paravina RD, Mielezsko AJ. *Fundamentals of Color: Shade Matching and Communication in Esthetic Dentistry*. 2nd ed. Hanover Park, IL: Quintessence Publishing Co., Inc.; 2010.
19. Berns RS. *Billmeyer and Saltzman's Principles of Color Technology*. 3rd ed. New York: Wiley, 2000, 75-104.
20. Shamey R. (Ed.) *Encyclopedia of color science and technology*. Springer Nature, 2023.
21. Ahn JS, Lee YK. Difference in the translucency of all-ceramics by the illuminant. *Dental materials*, 2008; 24:1539-154.
22. Egger B. Natural color concept: A systematic approach to shade selection *Quintessence of Dental Technology* 2003; 1-10.
23. Wasson W, Schuman N. Color vision and dentistry. *Quintessence Int* 1992; 23:349-353.
24. Della Bona, A., & Pecho Yataco, O. E. Avoiding Complications and Pitfalls with Color in Dentistry. *Color and Appearance in Dentistry*, 2020; 115-133.