

Perception and Practice of Shade Selection Principles among Postgraduates and Dental Practitioners in India: A Cross-sectional Survey

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ABSTRACT

Aims: The main purpose of this survey is to analyze the perceptions and practices of shade selection principles among postgraduates and dental practitioners in India.

Materials and methods: A well-formulated questionnaire consisting a total of 25 questions was disseminated among the postgraduates (Conservative Dentistry and Endodontics, Prosthodontics, Pedodontics) general practitioners, specialist practitioners (Conservative Dentistry and Endodontics, Prosthodontics, Pedodontics). The questionnaire includes knowledge and practice about shade selection principles and techniques. A total of 530 replies was accepted over Google forms. Responses were obtained from 266 postgraduates, 176 specialist practitioners, and 88 general practitioners. The data was analyzed using SPSS V25. Descriptive statistics were represented with percentages. The Chi-square test and Fisher's exact test were utilized to find the association between level of knowledge and level of practice with demographic variables ($p < 0.05$).

Results: Among the 530 respondents, 412 (77.7%) have poor/average knowledge and 118 (22.3%) have good knowledge of shade matching principles. There are 418 (78.9%) respondents utilized poor/average shade-matching practices. There are 112 (21.1%) respondents utilized good methods of practice for shade selection.

Conclusion: Among specialist practitioners, postgraduates, and general practitioners, the specialist practitioners had satisfactory knowledge and practices on shade selection. Knowledge and practice regarding the shade matching principles among the dentists were not adequate and Continuing Dental Education (CDE) programs on principles of shade analysis are recommended to regularly update the knowledge among the dental practitioners.

Keywords: Dental practitioners, Esthetic restorations, Perception, Shade matching.

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INTRODUCTION

Shade matching is a perplexing phenomenon in dentistry that comprises both visceral and objective phenomena.¹ Color perception is claimed to be associated with factors involving the visceral and emotional senses. It is a consolidation of physical perception, which includes a wavelength of light, psychophysical recognition which encompasses the recognition of light wavelength by the eye, and psychologic perception which includes discernment of light wavelength by the brain.² Cones and rods on the retina are responsible for the recognition of color, lightness, and darkness. Recognized wavelengths are then delivered as signals to the brain which decipher the signals into colors.³ According to Albert Munsell, color is measured by hue, value, and chroma.⁴ Hue is the interpretation of one color from another. Value is that quality by which we segregate a light color from a dark color.⁵ "Low" values describe dark colors and "high" values describe light colors. Chroma is the degree of intensity of the color tone (hue).⁶ Translucency, which is an important factor in the esthetic outcome of dental restorations, should be added to the above measurements.

As the incisal edges of human teeth are translucent, the meticulous scrutiny and reproduction of translucency are vital for their natural appearance.⁶

When presented separately, well-trained general practitioners and specialist practitioners can generally identify value and

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hue correctly. However, difficulties arise when they are coupled together, resulting in disagreement in value determinations in the selection of shade for esthetic restorations. Several factors influence an individual's color perception and evaluation, including clinical lighting conditions, availability of natural light, color blindness, eye fatigue, age of the individual, binocular differences, timing and method of shade matching, surrounding environment, condition of the tooth, patients opinion, and patients skin texture.⁷⁻⁹ But, even in the absence of the above factors, each individual will depict the color individually based on

his/her past experiences in color conception during shade analysis. Hence, meticulous training and education on color perception and shade selection principles should be the principal step that results in the predictable esthetic outcome of dental restorations.¹⁰ There is scarcity of literature regarding the color perception and shade selection principles in Indian context. Hence, the present survey aimed to evaluate the same among the general practitioners, specialist practitioners, and postgraduate students in India.

Table 1: Sociodemographic characteristics of dentists (*n* = 530)

Variable	Frequency (%)
Age group (years)	
20–30	352 (66.4%)
31–40	128 (24.2%)
41–50	40 (7.5%)
51–60	10 (1.9%)
Gender	
Male	210 (39.6%)
Female	320 (60.4%)
Cadre	
Postgraduates	266 (50.2%)
General practitioners	88 (16.6%)
Specialist practitioners	176 (33.2%)

Table 2: Knowledge about color perception and techniques of shade selection (*n* = 530)

Variable	Frequency (%)
Best time to perform shade matching	
10 am–2 pm	453 (85.4%)
Any time	49 (9.2%)
No idea	15 (2.8%)
4 pm–7 pm	13 (2.4%)
Ideal light source during shade matching?	
Natural day light	519 (97.9%)
Dental chair light	5 (0.9%)
LED light	3 (0.5%)
No idea	2 (0.3%)
Which of the following is ideal light with color temperature for shade selection?	
No idea	252 (47.5%)
5,500 K	234 (44.1%)
7,500 K	44 (8.3%)
Distance of the clinician eye to tooth while shade matching?	
25–35 cm	391 (73.7%)
10 cm	93 (17.5%)
No idea	46 (8.6%)

(Contd...)

MATERIALS AND METHODS

This cross-sectional survey was conducted systematically in August 2021, and the study was approved by the Institutional Ethical Committee (Pr.55/IEC/2021). A well-structured questionnaire with various options was prepared, and each question marked as obligatory was distributed using simple random sampling. A total of 25 questions began with an introductory revelation of the objective of the survey and emphasized the anonymity of each participant (Tables 1 to 4).

Table 2: (Contd...)

Variable	Frequency (%)
Which of the following plays a key role in shade matching?	
Value	180 (33.9%)
Hue	174 (32.8%)
Chroma	124 (23.3%)
No idea	52 (9.8%)
Do you think it is important need to take patients skin texture into consideration while shade matching?	
Yes	467 (88.1%)
No idea	32 (6.0%)
No	31 (5.8%)
What does the shade tabs A1–D4 (Example: A1, A2, B1, B2, C1, C2, D1, D2) in shade guide represents?	
Represent hue with increasing chroma within groups	206 (38.8%)
Represents both hue with increasing chroma within groups or value	158 (29.8%)
No idea	110 (20.7%)
Represent value	56 (10.5%)
Do you think color of the background in dental office will effect the shade selection?	
Yes	437 (82.4%)
No	54 (10.1%)
No idea	39 (7.3%)

Table 3: Practice about color perception and techniques of shade selection (*n* = 530)

Variable	Frequency (%)
Your preferred time to perform shade selection in your clinical practice?	
10 am	409 (77.1%)
Any time	95 (17.9%)
4 pm	23 (4.3%)
6 pm	3 (0.5%)
Do you think the use of the artificial light have any effect on the selection of shade?	
Yes	499 (94.1%)
No	17 (3.2%)
No idea	14 (2.6%)

(Contd...)

Table 3: (Contd...)

<i>Variable</i>	<i>Frequency (%)</i>
Do you take patients opinion during shade selection?	
Yes	483 (91.1%)
No	479 (8.8%)
Your preferred condition of the tooth while shade selection?	
Dry	232 (43.7%)
Wet	150 (28.3%)
Both dry and wet	148 (27.9%)
Method of isolation you prefer during shade selection?	
Not following any isolation method	217 (40.9%)
Cotton rolls	213 (40.1%)
Rubber dam	81 (15.2%)
Teflon tape	19 (3.5%)
What is the method that you follow during shade selection?	
Manual	442 (83.3%)
Combination of both	82 (15.4%)
Digital	7 (1.3%)
Your preference of time interval for shade matching?	
5–7 seconds	222 (41.8%)
10 seconds	169 (31.8%)
20 seconds	66 (12.4%)
30 seconds	44 (8.3%)
No idea	29 (5.4%)
If the time extends for shade selection, what is the procedure you prefer?	
Observe neutral grey or blue card between trials	378 (71.3%)
Continue to evaluate shade	81 (15.2%)
No idea	71 (13.3%)
During manual shade selection, where do you place shade tabs?	
Adjacent to the tooth to be matched	367 (69.2%)
Below the tooth to be matched	111 (20.9%)
Above the tooth to be matched	45 (8.4%)
No idea	7 (1.3%)
Your opinion on judgement of shade selection	
More desirable to select the shade before initiation of treatment	292 (55.0%)
More desirable to select both before initiation of treatment and after completion of treatment	183 (34.5%)
More desirable to select the shade after completion of treatment	55 (10.3%)
Which procedure do you follow during shade selection?	
Shade selection at incisal third, middle third, and cervical third of the tooth	343 (64.7%)

(Contd...)

Table 3: (Contd...)

<i>Variable</i>	<i>Frequency (%)</i>
Shade selection as a single unit	174 (32.8%)
No idea	13 (2.4%)
If you fail to select the shade in the appointment, which of the following method you follow?	
Recall the patient	272 (51.3%)
Select the shade at try-in stage	216 (40.7%)
Select randomly as A1 shade or B1 shade or any shade	42 (7.9%)
Which of the following shade guide are you using in your routine practice?	
VITA Classical A1-D4® shade guide (manual)	269 (50.7%)
VITA System 3-D MASTER shade guides® (manual)	149 (28.1%)
No idea	66 (12.4%)
VITA Linear guide 3-D MASTER® (manual)	32 (6.0%)
Automatic, instrumental shade selection techniques	14 (2.6%)
Do you prefer to use separate shade guides for ceramic restorations and for composite restorations?	
Yes	276 (52.0%)
No, universal shade guide for both ceramic restorations and composite restorations	254 (47.9%)
Your opinion on waiting time for shade selection after bleaching procedures?	
1 week	246 (46.4%)
1 month	159 (30%)
No idea	105 (19.8%)
Selecting the shade immediately after bleaching procedure	20 (3.7%)

Table 4: Opinion of respondents on attending CDE programs

<i>Variable</i>	<i>Frequency (%)</i>
Are you interested in attending CDE program on esthetic restorations?	
Yes	481 (90.7%)
No	49 (9.2%)
When did you attend your last CDE program on esthetic restorations?	
Not attended any CDE program	150 (28.3%)
Last 3 months	140 (26.4%)
Last 1 year	91 (17.1%)
Last 2 years	85 (16.0%)
Last 6 months	64 (12.0%)

Questionnaire

1. Best time to perform shade matching
 - a. 10 am–2 pm
 - b. Any time
 - c. No idea
 - d. 4 pm–7 pm
2. Ideal light source during shade matching?
 - a. Natural day light
 - b. Dental chair light
 - c. LED light
 - d. No idea
3. Which of the following is ideal light with color temperature for shade selection?
 - a. No idea
 - b. 5,500 K
 - c. 7,500 K
4. Distance of the clinician eye to tooth while shade matching?
 - a. 25–35 cm
 - b. 10 cm
 - c. No idea
5. Which of the following plays a key role in shade matching?
 - a. Value
 - b. Hue
 - c. Chroma
 - d. No idea
6. Do you think it is important to take patients skin texture into consideration while shade matching?
 - a. Yes
 - b. No idea
 - c. No
7. What does the shade tabs A1–D4 (example: A1, A2, B1, B2, C1, C2, D1, D2) in shade guide represents?
 - a. Represent hue with increasing chroma within groups
 - b. Represents both hue with increasing chroma within groups or value
 - c. No idea
 - d. Represent value
8. Do you think color of the background in dental office will affect the shade selection?
 - a. Yes
 - b. No
 - c. No idea
9. Your preferred time to perform shade selection in your clinical practice?
 - a. 10 am
 - b. Any time
 - c. 4 pm
 - d. 6 pm
10. Do you think the use of the artificial light have any effect on the selection of shade?
 - a. Yes
 - b. No
 - c. No idea
11. Do you take patients opinion during shade selection?
 - a. Yes
 - b. No
12. Your preferred condition of the tooth while shade selection?
 - a. Dry
 - b. Wet
 - c. Both dry and wet
13. Method of isolation you prefer during shade selection?
 - a. Not following any isolation method
 - b. Cotton rolls
 - c. Rubber dam
 - d. Teflon tape
14. What is the method that you follow during shade selection?
 - a. Manual
 - b. Combination of both
 - c. Digital
15. Your preference of time interval for shade matching?
 - a. 5–7 seconds
 - b. 10 seconds
 - c. 20 seconds
 - d. 30 seconds
 - e. No idea
16. If the time extends for shade selection, what is the procedure you prefer?
 - a. Observe neutral gray or blue card between trials
 - b. Continue to evaluate shade
 - c. No idea
17. During manual shade selection, where do you place shade tabs?
 - a. Adjacent to the tooth to be matched
 - b. Below the tooth to be matched
 - c. Above the tooth to be matched
 - d. No idea
18. Your opinion on judgement of shade selection
 - a. More desirable to select the shade before initiation of treatment
 - b. More desirable to select both before initiation of treatment and after completion of treatment
 - c. More desirable to select the shade after completion of treatment
19. Which procedure do you follow during shade selection?
 - a. Shade selection at incisal third, middle third, and cervical third of the tooth
 - b. Shade selection as a single unit
 - c. No idea
20. If you fail to select the shade in the appointment, which of the following method you follow?
 - a. Recall the patient
 - b. Select the shade at try-in stage
 - c. Select randomly as A1 shade, B1 shade, or any shade
21. Which of the following shade guide are you using in your routine practice?
 - a. VITA Classical A1-D4® shade guide (manual)
 - b. VITA System 3-D MASTER shade guides® (manual)
 - c. No idea
 - d. VITA Linear guide 3-D MASTER® (manual)
 - e. Automatic, instrumental shade selection techniques
22. Do you prefer to use separate shade guides for ceramic restorations and for composite restorations?
 - a. Yes
 - b. No, universal shade guide for both ceramic restorations and composite restorations
23. Your opinion on waiting time for shade selection after bleaching procedures?
 - a. 1 week
 - b. 1 month
 - c. No idea
 - d. Selecting the shade immediately after bleaching procedure

24. Are you interested in attending CDE program on esthetic restorations?
- Yes
 - No
25. When did you attend your last CDE program on esthetic restorations?
- Not attended any CDE program
 - Last 3 months
 - Last 1 year
 - Last 2 years
 - Last 6 months

A total of 530 replies were accepted over Google forms. Responses were obtained from 266 postgraduates (Conservative Dentistry and Endodontics, Prosthodontics, Pedodontics), 176 specialist practitioners (Conservative Dentistry and Endodontics, Prosthodontics, Pedodontics), 88 general practitioners. Inclusion criteria for the participants included being postgraduates from Departments of Conservative Dentistry and Endodontics, Prosthodontics, and Pedodontics, general practitioners, and specialist practitioners from Departments of Conservative Dentistry and Endodontics, Prosthodontics, and Pedodontics, who routinely perform esthetic procedures after taking consent. To check the validity of the questionnaire, they were sent to 20 experienced dental practitioners. Sociodemographic and professional components of the respondents were collected. The questionnaire evaluated knowledge and practice regarding color perception and techniques of shade selection.

Statistical Analysis

The data were documented in MS-Excel and scrutinized in SPSS V25. Descriptive statistics were described with percentages. The Chi-square test and Fisher's exact test were applied to find the association between level of knowledge and demographic variables, as well as level of practice and demographic variables. $P < 0.05$ was considered statistically significant.

RESULTS

A total of 530 responses included 266 (50.2%) postgraduates, 176 (33.2%) specialist practitioners, and 88 (16.6%) general practitioners. Most of the participants were aged between 20 and 30 years (352, 66.4%). The greater part of them was female (320, 60.4%) (Table 1).

Among 530 responses, 412 (77.7%) participants have poor/average knowledge and 118 (22.3%) participants have good knowledge of shade matching principles (Fig. 1). There are 418 (78.9%) respondents utilized poor/average practices on shade matching. There are 112 (21.1%) respondents utilized good methods of practice on shade selection (Fig. 2). The association between level of knowledge and demographic variables (Fig. 3).

A statistically significant difference ($p < 0.001$) was noticed among specialist practitioners (30.7%) postgraduates (22.2%), and general practitioners (5.7%) in terms of knowledge. No statistically significant difference was noticed in gender and among different age groups in terms of knowledge. The association between level of practice and demographic components (Fig. 4).

Statistically, a significant difference was noticed among different age groups ($p = 0.03$) with 18.2%, 37.5%, and 20% having good practice principles in the age groups of 20–30, 41–50, and 51–60 years, respectively. A statistically significant difference ($p < 0.001$)

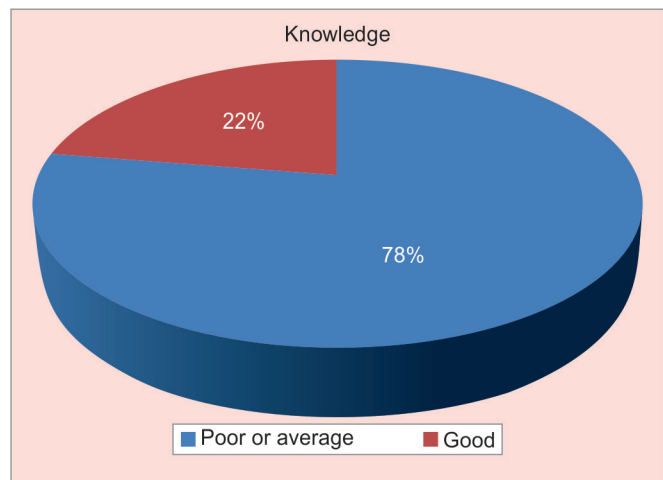


Fig. 1: Level of knowledge on shade selection

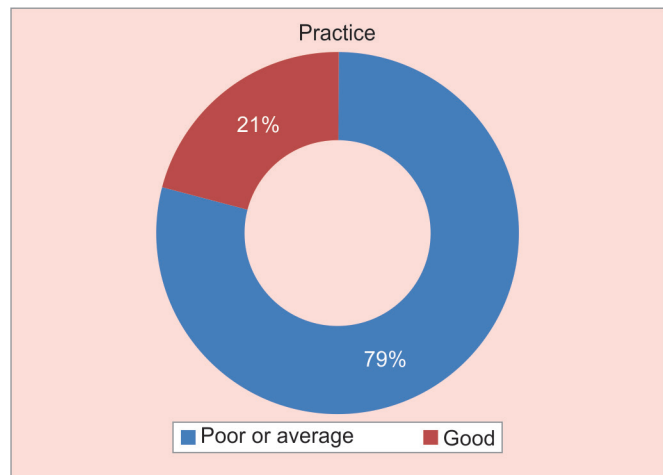


Fig. 2: Level of practices on shade selection

was remarked amidst specialist practitioners (31.8%), postgraduates (19.9%), and general practitioners (3.4%) in terms of the practice of shade principles. No statistically significant difference was remarked between gender and practice of shade principles.

DISCUSSION

Color perception predominantly relies on human physiology, which involves cone-shaped receptor cells. Because cone receptors in the retina fatigue and become sensitive to further stimulation, the selection of the shade ideally is done within 5–7 seconds. There are 222 (41.8%) respondents prefer to select the shade within 5–7 seconds. The eyes do not fixate at a single spot but rather wander the optical field continuously, especially when presented with two adjacent areas of different colors, resulting in the formation of overlapping afterimages. To overcome this, the eyes are given a break by looking at neutral gray or blue backgrounds.¹¹ There are 378 (71.3%) dentists prefer to observe at neutral gray or blue cards if time extends during shade matching. In this study, 283 (91.1%) dentists prefer to take patients' opinions during shade analysis and it has been recommended to take patients' opinions whenever shade selection is being made.¹¹

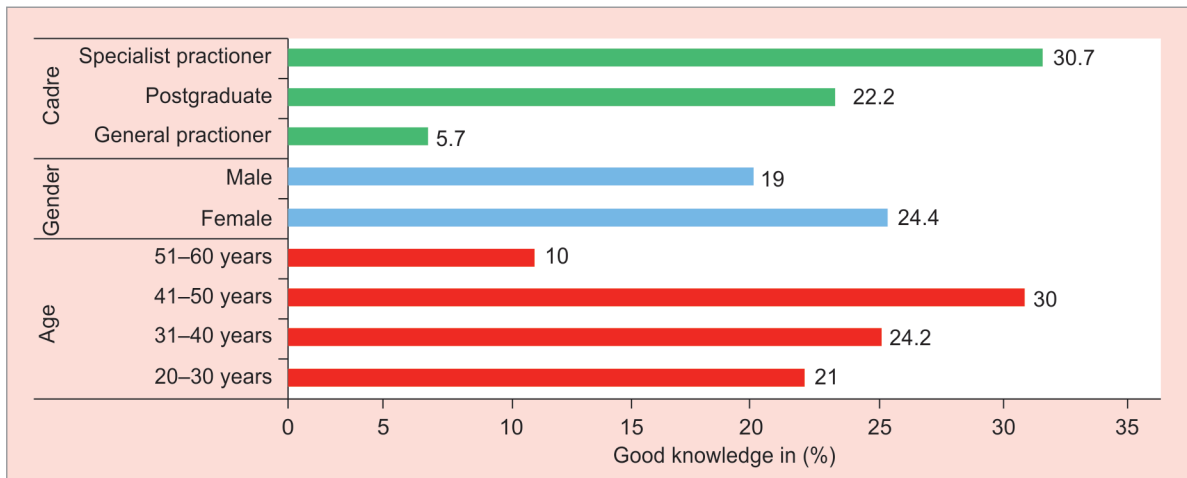


Fig. 3: Association between level of knowledge and demographic variables

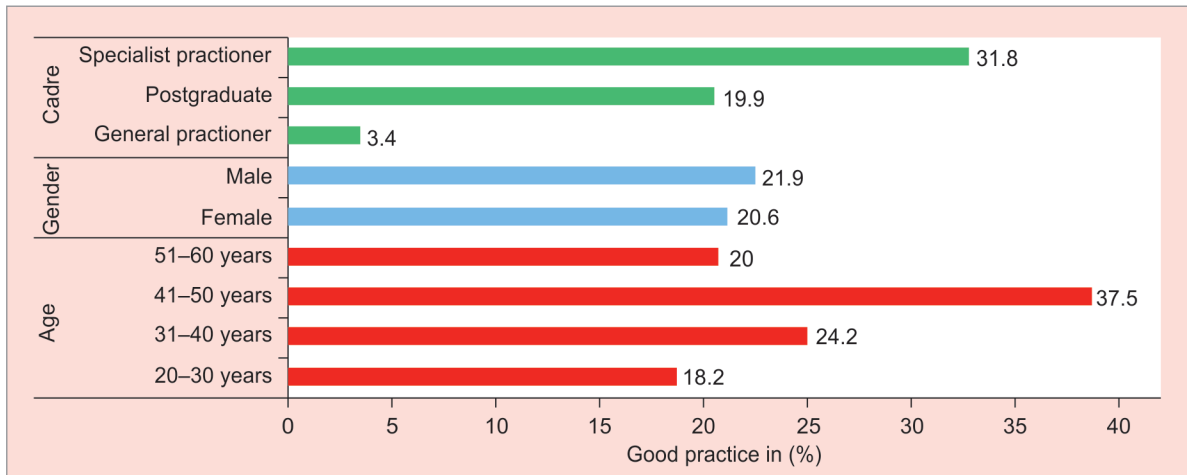


Fig. 4: Association between level of practice and demographic variables

Precise color perception and shade analysis are achieved with a lighting intensity of 150–200 foot candles with a color temperature of 5,500 K.¹² Intensity and quality of light in the operative field can be evaluated using a light meter and a color temperature meter, respectively.¹¹ The highest proportion of respondents 512 (97.9%) felt natural daylight is the ideal source of light for shade analysis. Best color perception can be achieved with color corrected lighting tubes with D 55 illuminants which produce the closest depiction to the natural sunlight.¹³ The best time to perform shade matching is between 10 am to 2 pm, according to 409 (77.1%) dentists. Use of dental chair light and incandescent bulbs is not recommended in the shade analysis because of a greater amount of yellow light eminence.¹¹

Perception of color is affected by the surrounding environment, including relative lightness, color, and saturation. Contrast effects are optical phenomena that can significantly modify color conception.¹¹ For best shade analysis, it is preferred to select the lighter shades for patients with lighter tones and vice versa to prevent the effects of value contrast effect.¹⁴ In the present study, 437 (82.4%) respondents felt that the surrounding environment have a profound effect during shade analysis. It has been recommended to remove the cosmetics that are applied on

the lips, as they affect the perception of the color during shade analysis.

There are 391 (73.7%) participants prefer to maintain a distance of 25–35 cm at the time of shade analysis. Tooth close to the viewer will appear larger and lighter and posterior teeth turn up darker. Hence, a 25 cm distance should be maintained from the patient's mouth to obtain a stable result.¹¹

In the current study, 367 (69.2%) respondents practice shade matching by placing the shade tabs adjacent to the tooth to be matched. When two objects are placed adjacent to each other with uniform illumination, a binocular color discrepancy occurs, i.e., one object turns up lighter than the adjacent object. During shade analysis, it is considered to placing the shade tabs either below or above the tooth to be matched, will helps to eradicate the binocular color discrepancy.¹¹

There are 246 (46.4%) respondents prefer to delay the shade analysis for 1 week after bleaching. Bleaching results in dehydration, brightening, and removal of pigmented stains between the hydroxyapatite crystals, thereby decreasing translucency and increasing the opacity of the enamel. Hence, shade analysis should be postponed for at least 1 month after bleaching for rehydration of enamel and to restore translucency.¹¹

There are 180 (33.9%) dentists felt that value is the most critical dimension for color perception in shade rendering. In the newly erupted teeth, the superficial enamel is highly reflective with high opacity and increased value. Because of the overlying young enamel, the underlying dentin, which represents the chroma of the tooth, will be lower. As the age increases, the upper layers of the enamel wear, the value decreases, and the chroma increases due to the secondary dentin formation. Value is the important color rendering element and should be measured first.¹¹

There are 292 (55.0%) respondents prefer to do the shade analysis before the initiation of treatment. Shade analysis must be done before you turn on the dental chair light and before initiation of treatment. Rods and cones in the retina of the eye are perceptive to light and result in eye weariness and glare.¹¹ There are 343 (64.7%) dentists prefer to select the shade for each of the three distinguishing color zones: gingival third, body, and incisal third. Color transitions in the surface change from one surface to another due to the difference in the thickness of enamel and dentin. To achieve the ideal color perception, the clinician must evaluate each of the three sections of the tooth, gingival, body, and incisal.¹¹

There are 217 (40.9%) respondents are not following any isolation method during shade analysis. There are 213 (40.1%) respondents chose cotton rolls, 19 (3.5%) used Teflon tape for isolation during shade analysis, and 81 (15.2%) used rubber dam. The dark value of the rubber dam sheet will trick the eyes into recognizing the tooth shade as being lighter. The final shade of the restoration will be too dark in consonance with the adjacent tissues.¹⁵ There are 232 (43.7%) respondents prefer to dry the teeth while shade matching. Chroma and translucency decrease and value increases on dehydration of teeth. Shade analysis must be carried out after cleaning the debris and the teeth must be in moist condition.^{16,17}

Most of the participants in the current study preferred to use manual shade selection over digital shade selection. Similar observations were made by Dagg et al. and Alruwaili et al.^{18,19}

There are 206 (38.8%) respondents felt that the shade tabs in the shade guide represent hue with increasing chroma within groups. 158 (29.8%) respondents surmised that shade tabs represent hue with increasing chroma within groups or value. There are 56 (10.5%) respondents felt that tabs in the shade guide illustrate only value. There are 110 (20.7%) practitioners have no idea what the shade tabs in the shade guide depict. Generally, shade tabs are arranged according to the value from lightest representing high value to darkest delineating low value, hue, and chroma, depending on the design of the shade guide. Shade analysis is better executed in the order value, chroma, and hue.¹¹

There are 269 (50.7%) practitioners prefer to use VITA Classical A1-D4° shade guide, 149 (28.1%) practitioners use VITA System 3-D MASTER shade guides°, 32 (6.0%) practitioners use VITA Linear guide 3-D MASTER° for shade analysis. There are 14 (2.6%) respondents practice computer-assisted shade analysis. It is advantageous to use independent shade guides for composite and ceramic restorations.²⁰ There are 276 (52.0%) respondents prefer to use separate shade guides for composite and ceramic restorations. There are 254 (47.9%) respondents use the same shade guide for both composite and ceramic restorations.

There are 481 (90.7%) respondents have shown interest to participate in the CDE program on esthetic restorations. There are 150 (28.3%) members have not attended any CDE program.

CDE programs play a pivotal role in understanding the potential factors affecting the perception of color and principles for shade analysis, thereby allowing the dental practitioners to redeem for them to attain the accurate shade analysis.²¹ Overall, specialist practitioners showed better knowledge and practice compared to postgraduates and general practitioners. This is in accordance with a study conducted among Nigerian dentists by Enone et al.²²

CONCLUSION

In comparison to postgraduates and general practitioners, the specialist practitioners had satisfactory knowledge and practices in shade selection. Due to the lack of color science knowledge, most dental practitioners were not well trained in the color perception and use of shade principles. CDE programs focusing on evidence-based esthetic dentistry, short courses on principles of shade analysis are recommended to regularly update the knowledge among dental practitioners.

DISCLOSURE

The preprint of this paper is deposited in the "Research Square" preprint platform. The DOI of the preprint paper is <https://doi.org/10.21203/rs.3.rs-1610885/v1> and the link is <https://www.researchsquare.com/article/rs-1610885/v1>.

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