

# Differences in Shade Perception among Post-Graduate Students and Dental Specialists

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## Abstract

**Background:** Attaining ideal esthetics in terms of accurate shade selection is fundamental in contemporary restorative dentistry, which is affected by multiple factors. Literature suggests varied response regarding shade matching among specialists and post-graduate students.

**Objective:** This study aimed to evaluate differences in shade perception between post-graduate students and dental specialists, focusing on their ability to accurately match hue and chroma using standardized shade guides.

**Methods:** A cross-sectional study was conducted among 156 participants at Khyber College of Dentistry, Peshawar including post-graduate students and specialists from various departments. Shade perception was assessed using four preselected VITA Classical shade tabs (C3, D2, B1, A4) under standardized lighting. Participants matched the hue and chroma of each tab using a separate shade guide. Data were analyzed using SPSS v25, chi square test and one sample t-test were used to identify statistically significant differences based on operator level with varying age and gender.

**Results:** Out of 156 participants, differences in shade perception between postgraduate students (n=132) and dental specialists (n=24) were evaluated across four shade tabs. Specialists demonstrated significantly higher accuracy in Tab 1 chroma matching ( $p=0.006$ ) and Tab 2 hue matching ( $p=0.005$ ), highlighting their superior performance. However, postgraduate students exceeded specialists in certain tasks, notably in Tab 4 chroma matching ( $p=0.106$ ), though this difference was not statistically significant.

**Conclusion:** While specialists showed superior shade perception in specific tasks, post-graduate students demonstrated comparable accuracy in many areas, indicating effective training. The findings suggest that experience enhances precision in shade-matching.

**Key words:** Shade perception, dental esthetics, visual shade matching.

## Introduction

Accurate color match of restoration and natural dentition is a very important aspect of dentistry to meet patients' expectations and acceptability of prosthesis.<sup>1</sup> For that reason, in composite restorations as well as ceramic restorations, accurate color matching skill is of profound importance in daily practice. Although color matching devices give more precise and

sound results as compared to optical shade matching, they do not contemplate many aspects related to teeth including tooth form, its transparency, shade variation, effect of surroundings, and lighting conditions. That is why, instead of completely relying on instrumental shade matching, it is only used in addition to visual color matching.<sup>2</sup>

Color is actually the light which an object reflects after absorbing some portion of it and is detected by photoreceptors i.e., rods and cones. Rods play their role in darkness, while cones take part in vision in daylight and hence detect colors.<sup>3</sup> Given that lighting plays a significant role in matching, manufacturers have developed lights that are meant to mimic optimal lighting conditions. Sunlight between noon and three in the afternoon and northern skylight has been recommended as most suitable.<sup>4</sup>

Accurate shade selection is essential for esthetic dental restorations, requiring clinicians to visually compare tooth shade with standardized shade guides. Although the VITA Classical guide

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Received: 22 October 2025, Accepted: 03 February 2026

Published: 28 April 2026

### Authors Contribution

A conceptualized the project. A, WT & FR did the data collection. A, WT & AZ performed the statistical analysis. A, AZ & SS did the literature search. Drafting, revision & writing of manuscript were done by A, WT & SNS.

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has long been considered the gold standard, the VITA 3D-Master system provides a more systematic distribution of hue, chroma, and value across the natural tooth spectrum.<sup>5</sup> Despite these advancements, visual shade matching remains unpredictable, as outcomes are affected by operator-related and environmental factors including experience, lighting, eye fatigue, and individual color-vision differences.<sup>6,7</sup> Human variability in perceiving subtle color differences often cause intra-operator discrepancies even under standardized conditions.<sup>8,9</sup> While some studies suggest women perform better in shade discrimination, others report no significant gender-based differences, highlighting ongoing debate in the literature.<sup>10</sup>

Study by G.E Adebayo suggests very low (3.8%) inter-examiner agreement in shade selection by the 3 examiners which shows differences in perception.<sup>11</sup>

In a recent study conducted locally by preesa salman et al reports that dental graduates were more competent in correct identified proper shade than dental students for sample I ( $p < 0.001$ ), II ( $p < 0.001$ ), III ( $p < 0.001$ ).<sup>12</sup>

Shade perception is well addressed in other countries having different demographic backgrounds, but shade selection ability among post-graduate students and dental specialists in our community is not addressed. This study highlighted the ability of shade selection by practitioners. There may be a need for the involvement of more than one person in the shade selection process.

The prime purpose of this study was to determine the difference in shade perception among post-graduate students and dental specialists. This study aims to assess and compare the shade perception accuracy between post-graduate dental students and dental specialists and to analyze whether clinical experience significantly influences the ability to correctly perceive dental shades.

## Methods

A cross-sectional study was conducted to evaluate shade perception among different dental practitioners. The sample size was calculated using WHO sample size calculator as 156, and the sample was selected using a convenience sampling technique. Postgraduate students and specialist dental practitioners from all departments (Prosthodontics, Operative Dentistry, Oral and Maxillofacial Surgery, Periodontology, Orthodontics, and Pediatric Dentistry) of Khyber College of Dentistry were included. Participants with diagnosed color blindness or uncorrected refractive errors (myopia, hyperopia, astigmatism).

Verbal informed consent was taken for agreement to participate in this study after describing the nature and purpose of the study and its possible benefits and harms. Participants' personal data (age, specialty, professional experience) was collected according to the proforma generated.

The whole shade-matching procedure was explained to each participant. Shade matching was performed in the same room for each participant. The VITA Classical shade guide was used for the purpose of color matching. One tab from each hue group (A, B, C, and D) was selected, and its written shade number was hidden. These were labeled as Tab1, Tab2, Tab3, and Tab4, respectively.

- C3 was selected as Tab1
- D2 as Tab2
- B1 as Tab3
- A4 was selected as Tab4

Shade tabs were displayed on a wall against a light grey background. The study participants were instructed to match each tab with a separate VITA Classical shade guide by bringing it close to the shade tab to be matched, using a standard color-corrected light source (Base Light 3 in 1 Tri-Spectra L.E.D. shade matching unit). The light was thrown on the specimen from a distance of one foot. First, the hue of the tab was matched with the portion of the tab with the highest chroma. The chroma was then matched in the selected hue group.

During this process, participants were given a light blue chart to counterbalance optic fatigue. There was no time limit to complete the test. To avoid mutual interactions among participants, a single participant was allowed in the testing room at one time. A separate shade guide was provided to match the color of the specimens displayed, one by one. Accurate matches were taken as 0 and incorrect matches were labelled as 1 in SPSS. The shade-matching ability was assessed by the researcher herself through an exact hue and chroma match of the selected tab with the separate shade guide provided. Data were analyzed using SPSS version 25. Mean and standard deviation were calculated for the numerical variables like age and experience in year.

Frequency and percentages were calculated for categorical variables like gender, age and operator level (dental students and specialists). The Chi-square test and t-tests were applied for normally distributed data. A Chi-square test or Fisher exact test was used to determine the differences in perception (shade matching quiz)

between operator level (dental students and specialists).

## Results

This study included 156 participants, of which 96(61.5%) were females and 60(38.5%) were males. Post graduate students were 132(84.6%) while Specialists were 24 (15.4%) in number.

For gender stratification only tab 4 showed significant results ( $p=0.03$ ) for both hue and chroma match with females showing more accuracy 54.2% (hue) and 97.9% (chroma). Males showed better performance in certain tabs but overall, females consistently demonstrated superior performance in chroma matching as well as hue matching in three out of four tabs, suggesting a generally stronger shade perception ability among female participants.

The hue match accuracy across four tabs, comparing postgraduate students with specialists, highlighting how operator level may influence shade selection precision. Only Tab 2 showed statistically significant ( $p=0.005$ ) results where specialist performed with higher accuracy. The chroma match accuracy of postgraduate students versus specialists across four tabs. In Tab 1, specialists significantly outperformed postgraduate students and this difference was statistically significant ( $p=0.006$ ). All other shade tabs showed non-significant results. Overall, specialists showed consistently better performance in chroma matching across most tabs, with a statistically significant edge in Tab 1. Group-wise mean comparison of hue matching and chroma matching accuracy between postgraduate students and specialists across four tabs was also considered. The means represent the proportion of correct hue matches (with 0 for correct and 1 for incorrect), while the standard deviations (SD) indicate the variability in responses. All comparisons are depicted in Table.

## Discussion

The current study aimed to explore differences in shade perception between

postgraduate students and dental specialists, focusing particularly on the accuracy of hue and chroma matching in various standardized tabs. Given the subjective nature of shade matching in clinical dentistry, where different individuals may perceive and identify the same shade differently, the study highlights the significance of both training and clinical experience in color matching tasks. Results showed that only Tab 4 chroma match yielded statistically significant differences ( $p=0.028$ ), indicating that specialists performed better in identifying chroma. This aligns with the findings of Žarko Udiljak and Hrvoje Pezo, who reported that specialists tend to show greater accuracy in shade matching.<sup>13</sup> In general, chroma matching accuracy exceeded hue matching across most specialties, underscoring the greater perceptual challenge associated with hue identification.

Gender-wise, the study did not find any statistically significant differences in shade matching, contradicting earlier findings by Jay Neitz and Gerald H. Jacob<sup>14</sup> and Oscar E. Pecho<sup>15</sup> who found females to be better at color matching. Interestingly, some literature even supports better performance by males,<sup>16</sup> but our data aligns more closely with M. Alomari and R.G. Chadwick,<sup>17</sup> who also found no significant gender-based differences. These results may have been influenced by the study's small sample size and the unequal distribution of male and female participants, which can limit the statistical power of gender comparisons. Therefore, while gender-related differences in color perception remain a debated topic, this study does not provide conclusive evidence in either direction.

Regarding clinical experience, shade matching performance did not show significant correlation on overall, except in Tab 2 hue match and Tab 4 chroma match, where more experienced participants demonstrated higher accuracy.

This suggests that although general experience may not universally enhance color perception, it can be beneficial in more nuanced or challenging shade assessments. Helene J. Haddad<sup>18</sup>

**Table: Comparison of Tab 1 to Tab 4 for Hue Match and Chroma Match stratified by Operator Level.**

Match Category		Operator Level		p-values	Operator Level	
		PGS n (%)	Specialist n (%)		PGS Mean (SD)	Specialist Mean (SD)
Hue	Tab 1	27 (20.5)	4 (16.7)	0.456	0.796 (0.40)	0.833 (0.381)
	Tab 2	28 (21.2)	12 (50.0)	0.005	0.788 (0.41)	0.500 (0.511)
	Tab 3	62 (47.0)	11 (45.8)	0.549	0.530 (0.50)	0.542 (0.509)
	Tab 4	61 (46.2)	13 (54.2)	0.310	0.538 (0.50)	0.458 (0.509)
Chroma	Tab 1	54 (40.9)	17 (70.8)	0.006	0.590 (0.493)	0.292 (0.464)
	Tab 2	87 (65.9)	18 (75.0)	0.266	0.340(0.476)	0.250 (0.442)
	Tab 3	114 86.4)	22 (91.7)	0.371	0.136 (0.344)	0.083 (0.282)
	Tab 4	127 96.2)	21 (87.5)	0.106	0.379 (0.192)	0.125 (0.338)

also concluded that experience level had no substantial impact on color selection, supporting the broader findings of our study. However, some contrary studies, like those by M.E. Miranda and others,<sup>19</sup> suggest better performance among more experienced individuals, especially postgraduate students. The conflicting findings in the literature suggest that while experience can enhance color-matching abilities, it may depend on the type and quality of clinical exposure, rather than just the number of years in practice.

Differences in performance were observed across age groups, though these differences were not statistically significant. The middle-aged group (35-45 years) demonstrated higher accuracy in chroma matching across Tabs 2 and 4, with accuracy rates of 70.6% and 88.2%, respectively, but the corresponding *p*-values (*p* =0.780 and *p* =0.114) indicate that these differences could be due to chance. While some studies suggest that aging reduces the ability to differentiate colors,<sup>20</sup> others argue that hue perception remains unaffected.<sup>13</sup> Our findings partly support both perspectives, suggesting that although visual acuity and color sensitivity may decline with age, professional experience in middle-aged practitioners might help mitigate these limitations. Additionally, the limited number of older participants in this study may have influenced the results, underscoring the need for age-stratified research with more balanced sample sizes.

The findings of this study reveal measurable differences in shade perception between postgraduate students and dental specialists, particularly in their ability to correctly identify hue and chroma across different tabs. Notably, Tab 2 hue match showed a statistically significant difference (*p* =0.003), with specialists demonstrating superior accuracy compared to students. This suggests that specialists, likely due to their advanced clinical exposure and refined diagnostic skills, possess a more precise perception of subtle color variations. Similarly, Tab 4 chroma match also revealed a significant difference (*p* =0.028), again favoring specialists, indicating their enhanced ability to assess color intensity and saturation, a critical skill in achieving esthetic outcomes in prosthodontics and restorative dentistry.

While other tabs did not show statistically significant differences, the trend across the data consistently points to slightly better performance by specialists, particularly in the more complex tasks of hue identification. For instance, although Tab 1 hue match (*p* =0.456) and Tab 3 hue match (*p* =0.549) were statistically non-significant, specialists still showed marginally higher correct match rates. This

pattern suggests that experience contributes to perceptual refinement over time, even if the difference is not always statistically evident. The relatively comparable performance of post-graduate students in certain tabs could reflect the evolving quality of dental education and early clinical training, which is helping to bridge the gap. Nevertheless, the observed differences emphasize the need for continued training in shade selection during postgraduate programs, especially targeting hue sensitivity, which appears to be more challenging for trainee practitioners. There was no time limit set for the shade matching procedure. Taking a longer time to match shades may have had a positive effect by allowing more precision, or it could have produced the opposite result due to eye fatigue. Another limitation was that the time of day was not specified, which may have influenced the outcomes. Participants who performed the matching earlier in the morning may have been more alert and accurate compared to those who undertook the procedure in the afternoon after a hectic day.

## Conclusion

This study concludes that while differences in shade perception between postgraduate students and dental specialists exist, they are not universally significant across all parameters. Notably, specialists demonstrated significantly better performance in specific areas such as Tab 2 hue and Tab 4 chroma matching, suggesting that clinical experience and specialization enhance the ability to perceive and match shades accurately. However, most shade-matching tasks showed no significant differences, indicating that postgraduate students are approaching competence levels comparable to specialists in many aspects. Factors such as age and experience showed varied influence on performance, highlighting the complex interplay of training, visual perception, and exposure. These findings underscore the importance of targeted training in hue and chroma matching within dental education to enhance esthetic outcomes in clinical practice.

**Funding:** None.

**Availability of Data:** The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

**Ethical Approval:** The Ethical Review Committee of Khyber College of Dentistry, Peshawar approved the study via letter no. 8152/RRB/KCD dated 12/01/2023.

**Conflict of Interest:** None declared.

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