EFFECTS OF THREE DIFFERENT LIGHTING CONDITIONS ON THE OUTCOME OF VISUAL TOOTH SHADE SELECTION USING THE VITAPAN CLASSICAL SHADE GUIDE

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ABSTRACT

Objective: *To evaluate the frequency of correct shade selections under three different lighting conditions using the Vitapan Classical shade guide among undergraduate dental students.*

Methodology: *This cross-sectional study was conducted at the Foundation University College of Dentistry (FUCD), from October 2024 to March 2025. Visual shade matching was carried out using a standard shade selection protocol to match a masked A3 shade tab to reference tabs under three different lighting conditions- natural daylight, standard operatory light, and color-corrected artificial light. A two-week interval was given between each trial. Shade agreement and selection time were measured. Statistical analysis was conducted using the Chi-square test and the Kruskal-Wallis test, with significance set at P < 0.05.*

Results: *A total of 95 dental students participated in the study, with a mean age of 25.06 ± 2.7 years. Among the participants, 31 (32.63%) were male and 64 (67.37%) were female. Shade agreement significantly varied with the type of light condition, with maximum accuracy under color-corrected light (62.11%), followed by natural sunlight (45.26%) and dental operatory light (32.63%) (p < 0.001). Time spent in shade selection was considerably less under color-corrected light (median = 28s) than natural sunlight (35s) and operatory light (37s) (p < 0.001).*

Conclusion: *Color-corrected lighting significantly improves shade-matching accuracy and efficiency compared with natural daylight or operatory light.*

Keywords: *Lighting conditions, Tooth shade selection, Vitapan Classical shade guide*

INTRODUCTION

It is crucial to attain the correct tooth shade match for successful aesthetic restorative care. Tooth shade choice can be performed with both visual and instrumental techniques[1]. Instrumental systems enhance objectivity, but visual shade matching with guide systems is the most prevalent clinical technique because of practicality and financial efficiency[2].

Visual shade selection is influenced by several clinical and environmental factors, including the light source, enamel translucency, patient age, and operator experience[3]. Among those factors, illumination conditions have been demonstrated to have a significant influence on dentinal color perception[4]. Natural daylight is usually the standard of reference, but is inconsistent because of weather- and time-dependent variations. Accordingly, artificial lighting sources, e.g., halogen and LED dental chair units, are common in dental operatories; however, differences in color temperature and intensity can affect perceived shade appearance[5,6].

Current research on dental education indicates that lighting quality can affect the consistency and reliability

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of visual shade selection, especially among inexperienced observers[7,8]. Moreover, accurate tooth shade selection is vital not only for aesthetic restorations but also for patient satisfaction and the longevity of restorations. Patients frequently perceive visual mismatches between natural dentition and restorative materials, which can lead to poor aesthetic outcomes or costly remakes[9]. Studies have shown that shade-matching accuracy improves when lighting simulates natural daylight — specifically, light sources with a color temperature near 5500 K and a high colour rendering index (CRI) enhance visual perception and inter-observer consistency[10]. Therefore, optimizing lighting conditions during shade selection is critical for minimizing human perception errors and achieving predictable aesthetic outcomes.

While earlier studies have examined various illumination conditions and their impact on shade matching, very little evidence exists comparing the frequency of correct shade choices and procedure time across the most commonly used light sources in standard clinical practice. This discrepancy underscores the importance of considering whether standardized or improved lighting conditions can enhance shade-matching results and support clinical education.

The objective of the current study was to evaluate the time and accuracy required for visual tooth shade selection using the Vitapan Classical shade guide under three lighting conditions by untrained dental observers.

METHODOLOGY

This cross-sectional study was conducted at the Foundation University College of Dentistry (FUCD), from October 2024 to March 2025, after the Institutional Review Committee of Foundation University College of Dentistry (FUCD) (ERC no: /632/ERC/56) granted approval. The sample size was calculated to be 95 using the WHO sample size calculator, with a confidence level of 95%, a population proportion of 0.148, and an absolute precision of 7%.

First to last year male and female BDS undergraduate dental students with normal or corrected visual acuity were taken as untrained observers, meaning they had no prior training in preclinical or clinical visual shade matching. Students who failed the Ishihara color vision test,15 with a history of migraine, or those using antidepressant or antipsychotic medications were excluded because these conditions and drugs are known to alter visual perception, particularly color discrimination and light sensitivity, which could negatively affect the accuracy of shade-matching and threaten the internal validity of the study.

Visual acuity was measured with a Snellen chart at 20 feet, and color vision was assessed with the Ishihara Test for Colour Blindness14 (Kanehara Shuppan Co., 2011 edition, Tokyo, Japan), in which correct recognition of all 10 plates was required. Each subject also gave written informed consent. A standardized shade-matching area was prepared in a 15 × 13-foot dental operatory, with controlled lighting and roller blinds over windows when necessary. A matte grey cloth covered the dental unit tray to serve as a neutral background. Participants were positioned at a constant distance of 60 cm from the shade-selection arrangement. Two Vitapan Classical shade guides were employed: shade A3 was chosen as the test shade and covered with opaque tape because of its widespread prevalence in South Asian dentition and its intermediate value range. While the second shade guide was the reference, with all the shade numbers exposed and numbered from 1 to 16. The actual correct shade was known only to the principal investigator (PI).

Each subject executed the shade-matching test under three independent lighting conditions to prevent interference from mixed light: (1) natural daylight at midday with blinds fully opened, taken as reference light ideal (~5500 K); (2) the standard dental unit LED light (4000–4500 K) representing typical clinical illumination; and (3) the handheld color-corrected LED light (Smile Line® Color Matching Light, 5500 K; CRI > 90), suggested to provide a better shade-matching accuracy. For lighting conditions 2 and 3, blinds were completely lowered to prevent external light. Within participants, the order of lighting exposure was randomized to preclude sequencing bias. Positioning of reference shade tabs was standardized but differed across lighting conditions to preclude familiarization bias: by hue in natural light, by value under dental unit LED light, and at random under color-corrected light.

Participants were asked to state, by word, the number on the nearest matching shade by reporting the written number on the tab they had chosen. The time taken for each try was measured to the nearest second with a digital stopwatch from the first sighting of the test tab until the verbal response. A two-week period between shade-matching sessions was inserted to minimize learning or recognition bias and prevent participants from remembering the positions of the shades. All the answers were recorded on a proforma containing structured demographic variables (age, gender, and year of study), accuracy of shade matching (correct/incorrect), and time taken. Participants were kept blind to their performance throughout to avoid response bias in later sessions.

The statistical analysis was carried out using the software Statistical Package for Social Sciences (SPSS) program, version 22.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics such as frequencies and percentages were obtained for shade-matching agreement

results, and median and interquartile ranges (IQR) were estimated for time taken since it was not normally distributed. The Chi-square test of independence was employed to assess shade-matching accuracy across the three lighting conditions, as it is suitable for categorical variables. Pairwise post-hoc comparisons were made with Bonferroni-adjusted Chi-square to account for Type I error.

Because the time data were not normally distributed (tested with the Shapiro–Wilk test), the Kruskal-Wallis H test was used to compare differences in shade-matching time among the lighting groups. In case of significance, Dunn's post-hoc test with Bonferroni correction was employed for multiple comparisons. Statistical significance was established at $p < 0.05$. Choice of statistical tests conformed to guidelines for assessing shade-matching performance in prosthodontic studies.

RESULTS

A total of 95 participants in the study had a mean age of 25.06 ± 2.7 years, of whom 31 (32.63%) were males and 64 (67.37%) were females. Among participants, 21 (22.11%) were first-year students, 24 (25.26%) were second-year students, 27 (28.42%) were third-year students, and 23 (24.21%) were fourth-year students.

Table 1 shows a comparison of participant responses during the shade-matching exercise under three different lighting conditions. The highest correct shade matching was observed under color-corrected light (62.11%), followed by natural sunlight (45.26%) and dental operatory light (32.63%). A statistically significant difference in correct shade matching existed between the three light conditions ($P < 0.001$). For the post-hoc comparison between the three light sources, there were significantly higher correct responses under color-corrected light than under natural sunlight illumination ($p = 0.020$) and dental operatory light ($p < 0.001$). There was no significant difference between natural daylight and dental operatory light ($p = 0.074$).

Table 2 shows that the lowest time spent on shade selection was under color-corrected light (median = 28 seconds), followed by natural sunlight (median = 35 seconds) and dental operatory light (median = 37 seconds). The time required for shade selection significantly differed among the lighting conditions ($p < 0.001$). Post-hoc analysis indicated significantly less time taken under color-corrected light than under natural sunlight ($p < 0.001$) and dental operatory light ($p < 0.001$). There was no significant difference in time required for correct shade matching when natural light and operatory light were compared ($p = 0.214$)

DISCUSSION

In the current study, color-corrected light not only achieved the highest frequency of accurate shade matches (62.11%) but also the shortest median shade-choosing time (28 seconds). This indicates that light quality influences both diagnostic accuracy and the operator's confidence. Surprisingly, natural daylight achieved higher accuracy than dental operatory light, despite being more heterogeneous, further buttressing the idea that most clinic lights are incapable of duplicating daylight's spectral distribution. The decrease in performance under dental operatory light (32.63%) underscores a clinically important deficiency in standard shade selection practice. Since improper shade matching is a frequent cause of aesthetic restoration remakes, these results support the use of color-corrected lighting aids in clinical practice, particularly for novice operators such as dental students.

In the current study, color-corrected light significantly improved shade selection accuracy, achieving 62.11% correct matches compared to 45.26% under natural daylight and 32.63% under dental operatory light. This improvement is likely attributable to the neutral color temperature (≈ 5500 K) and high color rendering index (CRI > 90) of the color-corrected light, which provide more consistent and balanced illumination, reduce perceptual distortion, and allow better discrimination of subtle hue and value differences. The shorter median selection time (28 seconds) under color-corrected light suggests that participants were able to make decisions more efficiently and confidently, reflecting increased visual clarity and reduced cognitive effort. Interestingly, natural daylight, although subject to minor variations, outperformed standard operatory lighting, emphasizing that many conventional clinic lights may inadequately reproduce the full spectrum of daylight, thereby reducing shade discrimination. The poorest performance observed under dental operatory light (32.63%) underscores the clinical importance of proper illumination, as insufficient lighting can compromise both accuracy and decision speed during shade selection, potentially leading to aesthetic mismatches in restorative procedures. Additionally, excluding participants with color vision deficiencies ensured that the observed differences were due to lighting quality rather than individual perceptual limitations. These results indicate that high-quality, color-corrected lighting alone can substantially improve both the accuracy and efficiency of visual shade selection among untrained observers. This observation is supported by multiple sources emphasizing the role of controlled and optimized illumination, standardized environmental conditions, and observer screening in enhancing shade selection outcomes[11–18]. In the present study, only the Vitapan Classic Shade Guide was used because it is still the most commonly used shade guide in clinics, is cheaper, and is more readily available than the 3D

TABLE 1: COMPARISON OF SHADE AGREEMENT USING THE VITAPAN CLASSICAL SHADE GUIDE UNDER THREE DIFFERENT LIGHT SOURCES

Light Source	Correct Shade Match n (%)	Incorrect Shade Match n (%)	p – value
Colour corrected light	59 (62.11%)	36 (37.89%)	
Natural sunlight	43 (45.26%)	52 (54.74%)	< 0.001*
Dental operatory light	31 (32.63%)	64 (67.37%)	
Post-Hoc Comparison (Bonferroni adjustment):			
Colour corrected light vs Natural sunlight			0.020
Colour corrected light vs Dental operatory light			< 0.001
Natural sunlight vs Dental operatory light			0.074

* Chi-square test applied

TABLE 2: COMPARISON OF TIME TAKEN (IN SECONDS) FOR SHADE SELECTION UNDER DIFFERENT LIGHT SOURCES USING THE VITAPAN CLASSICAL SHADE GUIDE

Light Source	Correct Shade Match n (%)	Incorrect Shade Match n (%)	p – value
Colour corrected light	28	8	
Natural sunlight	35	7	< 0.001*
Dental operatory light	37	11	
Post-Hoc Comparison			
Colour corrected light vs Natural sunlight			< 0.001
Colour corrected light vs Dental operatory light			< 0.001
Natural sunlight vs Dental operatory light			0.214

** Kruskal–Wallis test

Master Shade Guide. Moreover, the objective of the present study was to compare only the light sources. Saleem and Naeem[19] compared the shade selection of maxillary central incisors under natural daylight and in the operatory under artificial light in 67 patients. They achieved 70.1% concordance under natural daylight and 61.2% under artificial operatory light (p < 0.05). They did not state whether the operatory light was color-corrected or not. This was opposite to trend seen in the present study as color-corrected lighting was better than both natural and operatory light where 5500 K colour corrected light was used.

In future studies 3D Vitapan master, Ivoclar Vivadent, Noritake, Shofu Shade guides can be used to improve the accuracy of shade matching as these are considered to be superior. The sample size can be increased by including not just undergraduate dental students but patients and their attendants to get more accurate result that can be applicable on larger scale and help dentist achieve their esthetic outcome in diverse population.

CONCLUSION

This research supports that color-corrected light markedly enhances shade match accuracy and decreases selection time relative to natural daylight and traditional operatory lights. These results emphasize the necessity for standardized lighting during dental shade selection to provide consistent, predictable aesthetic results. Adoption of such protocols can enhance the efficiency of restorative and prosthetic dentistry and improve patient satisfaction.

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