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Clinical Comparision Of Traditional And Digital Techniques For Dental Shade Determination- An Invivo Study

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Abstract:
Background*: With rising demand for esthetic restorations, shade matching in dentistry blends art and science-affected by several external factors. While visual shade selection with a guide remains common for its simplicity, newer technologies like spectrophotometers and digital photography offer more objective, detailed color measurement and improved communication.*
Aim*: The aim of the study was to compare visual, spectrophotometric and digital photography methods for shade selection.*
Materials and Methods*: A total of 20 participants were selected for the study to evaluate and compare the accuracy of three shade selection methods: visual, spectrophotometric and digital photography. Visual method with standardized shade guide under consistent lightning. Spectrophotometric method providing $L^*a^*b^*$ values and corresponding shade, while digital photography method yielded only $L^*a^*b^*$ values obtained under standardized photographic conditions. The agreement among three methods was evaluated through statistical analysis, including ΔE^* calculations. Additionally, 10 participants with root canal treated maxillary anterior teeth had shade selection performed via same three methods. For each method, separate all-ceramic crowns were fabricated and assessed for shade match accuracy with the adjacent natural dentition using all three techniques. Comparative analysis was conducted to determine which method achieved the closest shade match to the natural dentition.*
Results*: A statistical analysis between all the three shade methods showed significant agreement($p<0.001$). These results showed that digital photography is a reliable method for clinical shade selection*
Conclusion: *Integrating digital photography into clinical practice can significantly improve the esthetic outcomes of dental restorations, leading to higher patient satisfaction and more predictable results.*
Key Word: *Dental shade selection; Digital photography; Spectrophotometry; Visual shade matching; Color accuracy; ΔE values; Esthetic dentistry; Shade communication; All-ceramic restorations; Lab* color system.*

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I. Introduction

The demand for highly esthetic dental restorations has increased significantly due to greater patient awareness and expectations. Accurate shade selection is a critical determinant of esthetic success, with improper shade matching being one of the most common reasons for remaking ceramic restorations[1]. However, shade selection remains a challenging and subjective process influenced by multiple factors, including lighting conditions, tooth morphology, surface characteristics, clinician perception, and patient-related variables.[2,3]

Visual shade selection using commercial shade guides is the most commonly employed method in clinical practice owing to its simplicity and accessibility. Nevertheless, this technique is highly dependent on human perception and is prone to inconsistencies.[4] Technological advancements have introduced objective

methods such as spectrophotometers, which measure reflected light across the visible spectrum, thereby improving accuracy and reproducibility.[5] Additionally, digital photography has emerged as an effective adjunct for shade determination and communication, allowing detailed color analysis through specialized software.[6]

Given the limitations of conventional visual methods and the growing emphasis on esthetic precision, evaluating and comparing different shade selection techniques is essential to improve the predictability and quality of esthetic dental restorations.

II. Material And Methods

This invivo comparative study was carried out on patients of Department of Conservative Dentistry and Endodontics, at Anil Neerukonda Institute Of Dental Sciences, Visakhapatnam, Andhra Pradesh from November 2014 to November 2015. A total 20 adult subjects (both male and females) of aged ≥ 18, years were taken in this study.

Study Design: Cross- sectional Invivo original research

Study Location: Department of Conservative Dentistry and Endodontics, at Anil Neerukonda Institute Of Dental Sciences, Visakhapatnam, Andhra Pradesh

Study Duration: July 2024 to October 2024

Sample size: 20 Patients.

Subjects & selection method: The study population was drawn from patients who presented to Anil Neerukonda Instute Of Dental sciences, Visakhapatnam from July 2024 to October 2024.

Inclusion criteria:

1. Participants between ≥ 18 years
2. Absence of intrinsic and extrinsic discoloration.
3. Presence of maxillary incisor teeth
4. Healthy periodontal status.

Exclusion criteria:

1. Presence of veneers, crowns or previous esthetic treatments
2. Teeth with severe discoloration, fluorosis, tetracycline staining
3. Poor oral hygiene
4. Pregnant women

Procedure methodology

20 participants were selected for the study. The shade of the maxillary incisor is determined using all the three shade selection procedures, namely, visual, spectrophotometric, and digital photography method for all the selected participants. The shades obtained in the visual method using a shade guide is noted down for further comparisons. The spectrophotometer reported the L*, a*, and b* values along with the actual shade whereas the digital photography method reported only the L*, a*, and b* values. The agreement between the readings obtained by the three different methods was compared and subjected to appropriate statistical analysis.

FIG 1: Visual shade selection using VITAPAN classical shade guide

FIG 2: Shade selection using VITA Easyshade Spectrophotometer

FIG 3: Shade selection using the digital photography method

10 participants among whom root canal treatment is completed were taken for the study. Shade selection is done by visual, spectrophotometric and digital photography methods for all the selected patients. The shade obtained from the visual method using shade guide are noted down. The spectrophotometer reported L*, a*, b* values and digital photography reported L*, a*, b* values are noted down. Crowns were fabricated with the shade obtained from each of the methods separately and compared between the crowns for appropriate shade.

Statistical analysis

Data were subjected to statistical analysis using Statistical Package for the Social Sciences (SPSS version 21.0, IBM Corporation, New York, USA).

For all the statistical tests, $P < 0.05$ was considered to be statistically significant.

III. Results

In this study, tooth color data—including shade designation and CIE L*, a*, and b* values—were obtained using three methods: spectrophotometry, visual assessment, and digital photography. The accuracy of shade matching achieved by a newly introduced digital photography technique and the conventional visual method was evaluated by comparison with spectrophotometric measurements, which served as the reference standard.

For comparison of shades between the visual, spectrophotometric and digital photography methods, the coefficient of agreement was checked. Results showed fair agreement between the three shade selection methods.

S.No	Spectrophotometer (L*A*B*)				Visual (Shade)	Agreement	Digital Photography (L*A*B*)		
1.	78.6	-1.6	9.6	A1	A1	YES	78.9	-2.1	11
2.	80.6	-2.0	14.5	D2	B2	NO	80.6	0.8	2.9
3.	82.5	-0.8	18.3	B2	B2	YES	82.9	-0.6	17.9
4.	71.6	4.6	30.6	A4	A4	YES	71.1	3.1	30.6
5.	79.3	-1.2	12.4	D2	B2	NO	82.2	-0.7	11.6
6.	87.8	-2.6	16.2	A1	A1	YES	86.1	-2.1	15.9
7.	78.8	-1.6	14.3	D2	D2	YES	78.1	-1.2	14
8.	84.2	3.4	33.3	A3	A3	YES	83.	3.1	29.4
9.	81.4	-1.8	15.8	D2	B2	NO	81.2	-1.2	15.2
10.	81.3	-1.7	14.9	D2	A2	NO	81.2	-1.9	11
11.	86.2	-2.2	17.2	A1	A1	YES	85.9	-2.3	17.6
12.	82.9	-2.9	10.9	B1	B1	YES	82.6	-2.1	13
13.	69.6	-1.3	11.6	C2	C1	NO	76.5	-2.6	13
14.	83.0	-1.7	25.3	B2	B2	YES	82.7	-1.7	22
15.	77.7	-1.5	12.7	D2	D2	YES	78.1	-1.6	11.9
16.	72	-1.3	13.2	C2	C2	YES	72.6	-1.4	13.6
17.	76.8	3.0	10.6	D2	A1	NO	83.1	-2.6	13
18.	73.2	-1.6	12.2	D2	D2	YES	73.9	-3.1	12.4
19.	83.9	-2.3	15.2	A1	A1	YES	84.1	-0.94	15.7
20.	66.8	-0.6	20.9	C3	C3	YES	73.2	-0.7	19.6

Clinically, crowns fabricated using all three shade selection methods showed comparable shade-matching outcomes; however, crowns fabricated using the digital photography method exhibited more accurate shade matching with the adjacent natural tooth.

IV. Discussion

Accurate shade selection is fundamental to the success of esthetic dental restorations, as even minor discrepancies can compromise patient satisfaction and clinical outcomes. The present study compared visual, spectrophotometric, and digital photography methods for shade selection and demonstrated significant agreement among all three techniques, with digital photography showing reliable performance for clinical application.

Visual shade selection remains the most commonly used method in clinical practice due to its simplicity and cost-effectiveness. However, it is highly subjective and influenced by several variables, including lighting conditions, observer fatigue, color perception, and surrounding environment. Despite these limitations, the present study found significant agreement between the visual method and instrumental techniques when standardized lighting and shade selection protocols were followed. This finding supports previous studies suggesting that controlled clinical conditions can improve the reliability of visual shade matching.[7,8]

Spectrophotometric shade selection is considered one of the most objective methods, as it quantifies tooth color using CIE L*a*b* values and minimizes human bias. In the current study, spectrophotometric measurements showed strong agreement with both visual and digital photography methods. This corroborates

earlier research reporting high accuracy and reproducibility of spectrophotometers in dental shade analysis. However, factors such as high cost, technique sensitivity, and limited access may restrict their routine use in everyday clinical practice.[9]

Digital photography demonstrated comparable accuracy to spectrophotometric analysis in this study, with statistically significant agreement ($p < 0.001$). The ability of digital photography to capture detailed color information, combined with software-based L*a*b* analysis, allows for comprehensive shade evaluation of the entire tooth or specific regions. Additionally, digital images enhance communication between clinicians and dental technicians, reducing the risk of misinterpretation during restoration fabrication. These findings align with previous studies that have reported digital photography as a reliable and practical alternative for shade selection, particularly when standardized photographic protocols are employed.[6]

In participants with root canal–treated maxillary anterior teeth, the use of digital photography and spectrophotometric methods resulted in crowns with closer shade matching to adjacent natural teeth compared to visual assessment alone. This highlights the importance of objective shade selection methods in challenging clinical scenarios, such as non-vital teeth, where color variations are more pronounced.

Despite its positive findings, this study has certain limitations. The sample size was relatively small, and shade matching was assessed under controlled conditions, which may differ from routine clinical environments. Additionally, variations in camera systems, software calibration, and operator experience may influence the accuracy of digital photography. Future studies with larger sample sizes, different ceramic systems, and long-term clinical evaluations are recommended to further validate these findings.

Overall, the results of the present study support the growing body of evidence that digital photography, when used with standardized protocols, offers a reliable, accessible, and effective method for dental shade selection and can serve as a valuable adjunct or alternative to conventional techniques.

V. Conclusion

All three shade selection techniques—visual, spectrophotometric, and digital photography—showed strong agreement in shade determination within the constraints of this investigation. However, digital photography provided objective L*a*b* analysis and enhanced communication with dental technicians, demonstrating great clinical dependability and performance comparable to spectrophotometric tests. The results imply that the accuracy and predictability of shade matching for aesthetic restorations can be improved by integrating standardized digital photography into routine clinical practice, which would eventually improve aesthetic results and patient satisfaction. These findings are in line with earlier studies showing that spectrophotometric and digital imaging techniques typically produce more accurate shade matching than conventional eye evaluation alone.

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