Comparison of Shade Matching in Prosthodontics: Visual selection versus the use of a Gray Card.

Shanmuga Shri Vidhya Konda Gokulnath Varalakshmi[1], Dr Bharanija Kalidasan Selvi[2], Dr Annapoorni Hariharan[3]

[1]*Undergraduate student, Meenakshi Ammal Dental College and Hospital, Faculty of dentistry, MAHER, Chennai, Tamil Nadu, India*

[2]*Professor, Department of Prosthodontics, Meenakshi Ammal Dental College and Hospital, Faculty of dentistry, MAHER, Chennai, Tamil Nadu, India*

[3]*Professor and Head, VP(Academics), Department of Prosthodontics, Meenakshi Ammal Dental College and Hospital, Faculty of dentistry, MAHER, Chennai, Tamil Nadu, India*

Abstract- Clinical failure can result from a variety of reasons that impact the aesthetics of dental prostheses, including the instrumental approaches utilized in shade matching. The purpose of this study was to assess the impact of clinical experience level on shade matching success and compare the efficacy of visual selection and gray card use for shade matching.

I.INTRODUCTION

Choosing the right tooth shade is crucial to getting aesthetic restorations that look well. Shade selection can be done by visual method or using instruments like intraoral digital scanners, spectrophotometers, or gray cards[1–4] . The expectations and needs of patients regarding aesthetics are rising. Shade matching, which aims to match the prosthesis' colour to the surrounding residual teeth, is just as important as the prosthesis' design for the effectiveness of aesthetic treatment. The evaluation, documentation, and replication of tooth colours are limited by the diverse shades of natural teeth, which are affected by environmental conditions[5]. Furthermore, laboratory staff must be adequately informed of this knowledge in order for them to construct prostheses in shades that blend in with their environment.

Three main elements affect how colour is perceived: the environment, the item being examined (tooth or shade tab), and the light source (illuminant). Metamerism is the term for the phenomenon whereby slight variations in these factors can change the teeth's apparent hue, chroma, and value. According to clinical research, backgrounds with strong chromatic elements, including operatory upholstery, lipstick, or vividly coloured apparel, might distort perception by producing simultaneous contrast effects[6]. The colour of the background can influence the perceived brightness of a tooth, leading to either overestimation or underestimation, even under standard daylight illumination. To ensure visual consistency and enhance measurement repeatability, the use of a neutral or achromatic reference - such as an 18% gray card has been advocated.

A gray card provides a neutral field with uniform reflectance across the visible spectrum. Viewing the card briefly allows the retina to "reset",helping the observer establish a more stable baseline for shade evaluation and reducing afterimages and visual fatigue. Gray cards are commonly utilized in dental photography for colour correction and white-balance calibration, and recent studies suggest that their use during chairside shade matching offers similar advantages. It has been reported that employing a gray background minimized the effects of lighting variability and significantly enhanced inter-observer agreement. Likewise, some other authors also found that visual shade matching performed against a gray background resulted in a higher rate of accurate shade selections compared to colourful, black, or white backgrounds [6].

The current study compares the accuracy of shade matching utilizing a gray card as a neutral background in a controlled clinical setting with that of traditional visual shade selection. This study aims to determine whether using a gray card can improve prosthodontic practice in a quantifiable way by measuring the variations in shade agreement between the two approaches. These results could direct medical professionals toward evidence-based procedures that improve aesthetic results while remaining easy to use and reasonably priced.

II.MATERIALS AND METHODS

The Vitapan Shade Guide, also called the VITA Classical A1-D4 Shade Guide, was used to analyze the colour of the maxillary right central incisors of 60 subject models. Reddish-brownish (A1-A4), reddish-yellowish (B1-B4), grayish (C1-C4), and reddish-grayish (D2-D4) are the hue-based groupings into which it divides the 16 hues. After being cleaned and undergoing tooth colour shade selection using gray cards, the natural maxillary right central incisors were found to be in good health, undamaged, and unbleached.

The Objective method: With the Vitapan Shade Guide 1 perfect shade and another near matching shade was selected visually under natural day light settings. The tabs from shade guides have been scored based on their lightness in order to analyze the data gathered from visual analyses.

Gray card method: Photographs of the models were taken with natural day light settings using a gray reference card and colour analysis was performed from the same spot.

For accurate shade selection, with neutral gray background, shade matching was performed between 10 a.m. and 2 p.m. using natural daylight.

Figure 1: Digital photograph of the maxillary right central incisor captured with a gray card and shade tabs from the closest matching values (D2,D3).

III.TECHNIQUE

1. Hold the VITA Classical A1-D4 Shade Guide at arm's length close to the patient's mouth while they are sat upright in the dental chair with the occlusal plane of their maxillary teeth parallel to the floor. Choose shade tabs from each value group of the VITA Classical A1-D4 Shade Guide that are closer in value to the tooth that needs a shade match.

2. Using the gray reference card (DentCare) and selected shade tabs near the tooth of interest, take a picture with a smartphone camera (Redmi Note 12 Pro; Xiaomi) in natural daylight (Fig. 1).

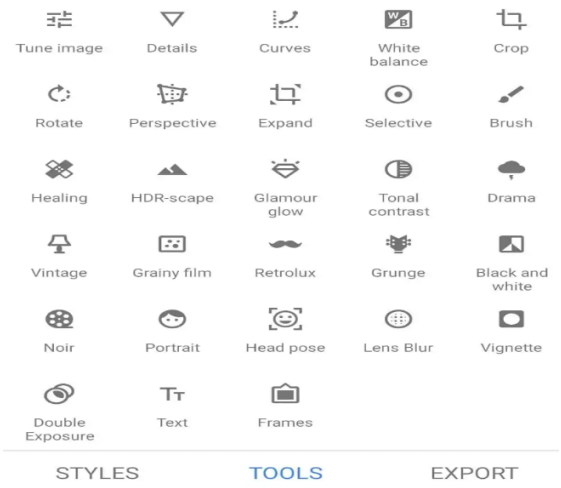
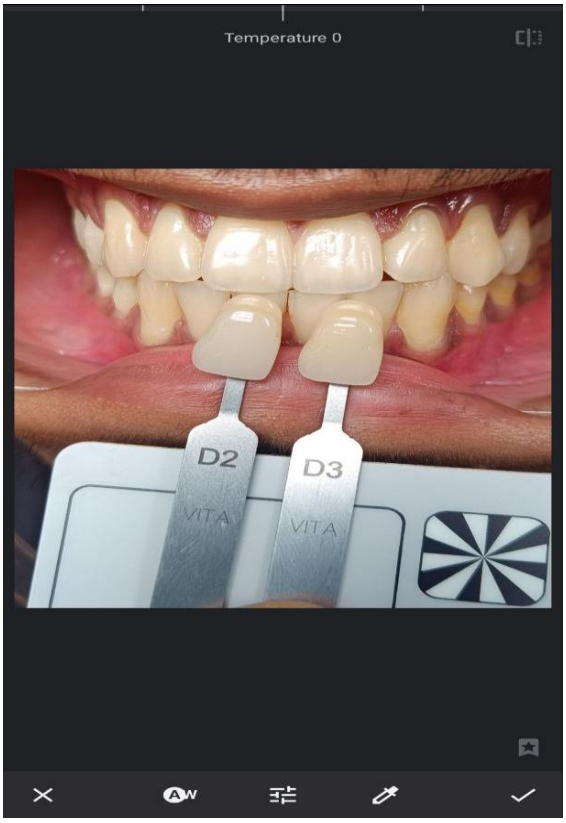


Figure 2. White balance, black and white and Tune image option from tools menu.

3. Save the picture that was taken in step two and transfer it into the smartphone app that edits photos (Snapseed; Google LLC)

4. From the "Tools" menu, choose the "White balance" option (Fig. 2). To normalize the digital image through colour correction, use the "Colour Pick" tool and move the cursor over the gray card area (Fig. 3).



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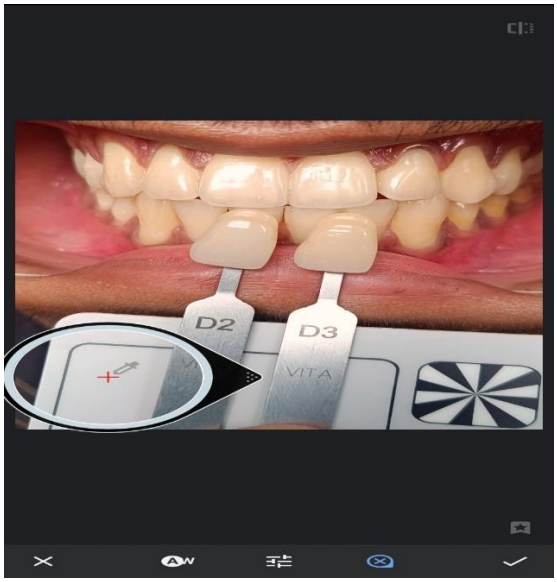
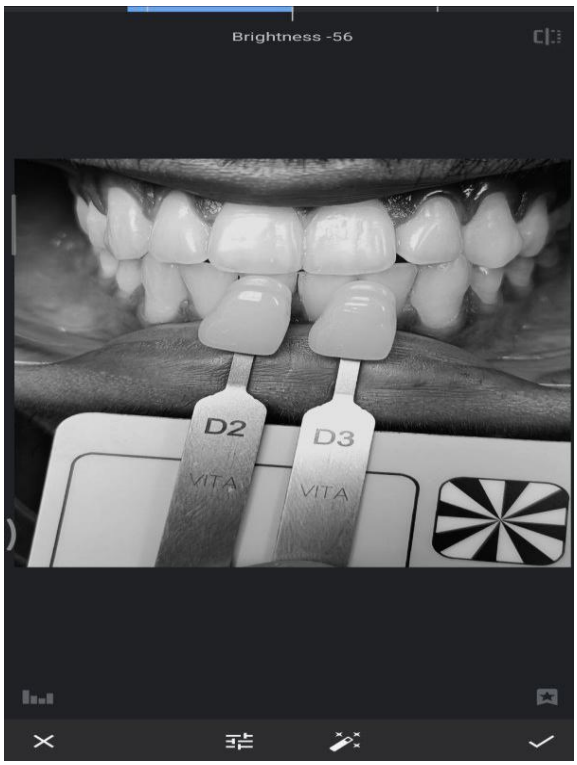


B

Figure 3: Standardization of the photographic image by colour correction. (A) Image displayed in the white balance tool before correction. (B) Colour correction performed using the colour pick tool.

5. From the app's "Tools" menu, choose the "Black and white" option. Select the "Tune image" option, then adjust the brightness and contrast until it is easy to see the shade tab selection depending on value (Fig. 2). Choose the tab with the closest value by comparing the shade tabs with this setting (Fig. 4). [7]



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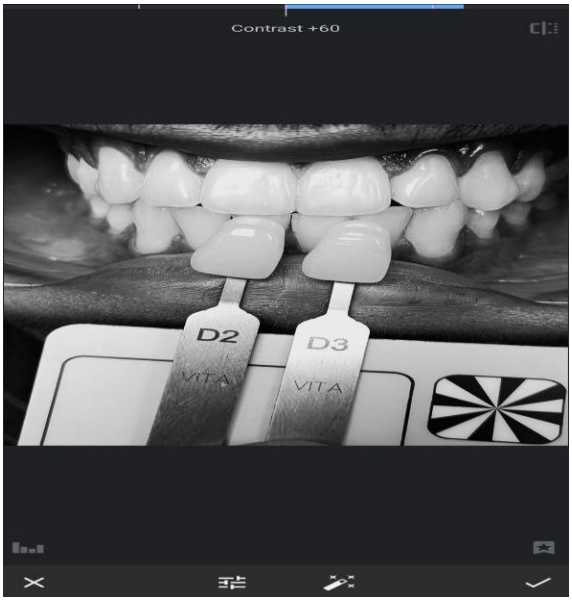

B

Figure 4: Adjusting brightness and contrast for chroma selection concludes D2 as closest matched shade tab. (A) Brightness decreased. (B) Contrast increased

This study was conducted as a cross-sectional observational study over a 10 days period of time in a tertiary care hospital in Chennai. The study population comprised of patients aged 18 years and above visiting the Outpatient Department (OPD) during the study period.

Sampling and Participants

A convenience sampling method was adopted, whereby participants were recruited from those available and willing to take part in the study.

IV.RESULTS

The natural tooth colour of 60 patients was assessed. Among them, 80% showed a match with the first selected shade, while 20% matched with another closely related shade when photographs taken with a gray card were evaluated.

This study compared the accuracy of conventional visual tooth shade selection with a standardized method combining gray card calibration and smartphone-based evaluation. Visual shade selection, though widely practiced, depends on the clinician's colour perception and surrounding illumination, introducing subjective variation that often leads to mismatch between clinical and laboratory shade outcomes.

The use of a gray card provides a neutral reference with defined reflectance properties, enabling accurate white balance calibration. This minimizes

the influence of ambient light variations and background colours, ensuring standardized shade assessment. Gray card–assisted photography allows clinicians to evaluate value, chroma, and hue with improved consistency. The accompanying smartphone application facilitates grayscale conversion to verify value, followed by fine adjustment for chroma and hue, resulting in better shade communication between clinician and technician.

Overall, gray card–assisted shade selection demonstrated greater precision and reproducibility than visual methods alone. It minimized subjective variation, improved workflow efficiency, and enhanced esthetic outcomes.

V.DISCUSSION

Accurate shade matching is crucial for achieving natural and esthetic restorations in prosthodontics. Although visual shade selection remains the most commonly used method due to its simplicity and low cost, it is influenced by factors such as ambient lighting, background colour, observer fatigue, and individual colour perception. These limitations reduce reliability and can result in inconsistent shade matching and patient dissatisfaction[1].

The gray card method improves shade accuracy by providing a standardized reference with 18% reflectance. This allows proper white balance correction and neutralizes lighting and background effects—two key sources of colour discrepancy. The technique also minimizes metameric and simultaneous contrast effects, enhancing agreement among clinicians and between clinical and laboratory assessments[6,7,9].

Images captured using gray card calibration can be analyzed through simple photo editing applications to determine value, chroma, and hue. Value assessment, being less affected by human colour bias, improves consistency and objectivity[10]. In contrast, purely visual matching is prone to subjective error due to inconsistent lighting and fatigue. Gray card calibration provides a controlled colour environment, improving reproducibility and communication with dental laboratories[5].

Although spectrophotometers and colorimeters offer excellent precision, their high cost and complex operation limit everyday clinical use. The gray card–based digital method, however, is inexpensive, accessible, and compatible with standard smartphone cameras, making it suitable for routine clinical application.

Limitations include dependence on proper image acquisition protocols, operator experience, and camera quality. Nonetheless, it significantly reduces perceptual bias and lighting variability. With further refinement and the possible integration of artificial intelligence, the gray card method may evolve into a standard digital shade-matching protocol[10].

VI.CONCLUSION

Within the limitations of this study, it can be concluded that gray card–assisted shade selection provides superior accuracy, reproducibility, and communication compared to conventional visual methods. It is a simple, cost-effective, and clinically feasible approach recommended for routine prosthodontic practice to enhance esthetic predictability and patient satisfaction.

Conflicts of Interest:

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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