Comparison of three different methods of shade selection using visual, digital and smartphone photographic methods.

Jayasurya[1], S. Sabarinathan[2], M Sibi Shalma[1], Geerthana Janakiraman[1], R. Lambodharan[3].

[1]Post graduate student, Department of Prosthodontics, CSI College of Dental Sciences and Research, Madurai, Tamil Nadu.
[2]Professor, Department of Prosthodontics, CSI College of Dental Sciences and Research, Madurai, Tamil Nadu.
[3]Professor and Head, Department of Prosthodontics, CSI College of Dental Sciences and Research, Madurai, Tamil Nadu.

Abstract

Background: The determination of an accurate shade for restoring the natural shade of the teeth, conveying it to the dental laboratory technician and satisfying the aesthetic expectations of the patient in this modern technology driven world, has become an uphill battle for the dental practitioners.
Aim: The aim of this study was to compare various methods of shade selection namely- visual method, digital photograph method and smartphone photograph method.
Materials and methods: Twenty-five random subjects of age ranging from 25 to 40 years were selected from the outpatient department. Right maxillary central incisor tooth presence, which had not undergone any prior restorative, endodontic or orthodontic procedures was the primary inclusion criteria. The shade selection procedure was performed using all three methods. The shade selected using the shade guide in the visual method was noted along with its corresponding L*, a* and b* values. The smartphone photograph and digital photograph methods provided these values of the subject using different software which were noted for further comparison. The data thus obtained, then underwent statistical analysis.
Results: The results showed that there is a significant difference in L*, a* and b* values between the three groups. One-way ANOVA was done since there were more than two groups in the study. During intergroup comparison using ANOVA, a significant difference was noted in all parameters (L*, a* and b*) among the three methods of estimation *P* value was 0.0001 ($P<0.01$)
Conclusion: It was concluded that with the help of further research and standardization procedures the best method for shade selection for a successful aesthetic restoration can be determined.

Keywords- Digital photograph, shade selection, smartphone photograph, visual shade matching.

Address of correspondence: Dr. Jayasurya, Department of Prosthodontics, CSI College of Dental Sciences and Research, Madurai, Tamil Nadu.
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Introduction

The chase for aesthetic excellence in dentistry is at present driven by the standards set by the omnipresent social media and the ever evolving digital multimedia communication systems,[1–4] rather than valuing the oro-dental function of a aesthetic restoration. A proper understanding about light's nature, and how the human eye perceives it, and the interpretation of the colour by the brain is of prime importance for successful aesthetic restorations, specifically in case of all-ceramic or metal-ceramic restorations.

Successful shade matching of a restoration pertains to the selection of appropriate shade and its impeccable replication.[5] The replication process for a dental material is based on the power to accurately and simultaneously be consistent in measuring the tooth colour.[6]

The conventional way of shade matching utilising shade guide is a very common method and is a relatively simple procedure.

The certainty provided for the aesthetic outcome, of the restoration where the shade is selected using shade guides, may be lacking, but may not be blamed on the method of determining the shade itself.[7] Shade guides have functioned as tools for colour communication.[5] However they are also an intermediary step and therefore bring about two means of error: first through the dental professional and second via the laboratory technicians in the dental lab setup. The process of shade selection is regarded to be a subjective judgement, even amongst highly experienced clinicians under ideal conditions.[8–10]

Researchers have concluded that the human brain has the potential to distinguish about one million colour shades, whereas the latest designed electronic devices can sense around ten million different shades. These electronic gadgets can assort and identify about 100,000 distinct dental shades, whereas the eye of humans are only capable of distinguishing 1% of these dental hues .[11]

Shade matching via digital means is adapted from the concept of colour spaces or models, where specific numbers are assigned to the colours.[12] The International Commission on Illumination proposed the CIE L*a*b* colour order system, in the year of 1931.

A particular shade is determined by its position in the CIE L*a*b* system defined by three coordinates L*, a* and b* values. L* represents the lightness. a* and b* depict the colour's chromatic attributes, wherein a* indicates the axis of red-green colour and b* indicates the yellow-blue axis.

Non-proximity equipment such as professional use digital cameras, intraoral dental cameras and smartphone cameras[13] have been used in shade matching in dentistry. Digital cameras are one of the most basic electronic methods of shade assessment. Numerous researchers have reached the conclusion, pronouncing digital cameras as reliable tools for the estimation of colour of gingiva and teeth, provided they are used in conjunction with proper standardization protocols.[14]

The aim of this study was to juxtapose three different methods of shade selection using visual method, digital photograph method and smartphone photograph method.

Materials and methods

The sample size is chosen according to the findings obtained from prior published studies. The sample size of twenty-five cases was chosen. Approval was obtained from the Institutional Ethical Committee. Twenty-five patients were chosen at random from the outpatient department. The shade matching protocols, were performed on the right maxillary central incisor on the subjects after obtaining their informed consent. The inclusion criteria required the presence of natural maxillary right central incisor which had not undergone any endodontic or restorative or orthodontic procedures. The age group of the subjects was between 25 and 40 years, as the shade is significantly regulated by age.[15]

For standardization of the study, the same investigator did all the methods of shade selection. The subjects were asked to sit on the same dental chair for the procedure when the light temperature was around 4000-5000 Kelvin.

In the visual shade selection process, to address the potential issues of colour blindness, and to avoid shade disparity the operator undertook pseudochromatic colour plate test and Munsell colour test described by Farnsworth.[15]

The Vita System 3D-Master (VITA, Germany) shade guide was the tool of choice for the visual method. After moistening the teeth, the maxillary right central incisor's middle third was chosen as the site for shade selection. The shade guide was positioned directly in front of the chosen tooth and the lightness level (0-5) was determined from the

nearest shade colour. Next, the chroma was determined within the hue group according to the level of saturation of colour. The sample selected is checked to see if the dominating colour is yellow (L) or red (R). The appropriate shades were noted down for each subject based on their corresponding shade tabs. The L*a*b values were logged for the selected shade as provided by the shade tab manufacturer.

Digital photography method employed Canon 1200 D series camera and a Harison tripod stand (3D EV) used for stabilization. The features of the camera were set according to the settings listed in Table 1. A HP Pavilion laptop containing the Adobe Photoshop CS6 software used for analysing the images was utilised.

The following procedure was employed for capturing the image of every subject. The patient's cheek was retracted using a cheek retractor. The camera's vertical arm was adjusted to align with the patient's occlusal plane, while ensuring the perpendicular orientation of the camera's optical axis to the patient's frontal plane. A gap of 17 cm was maintained between the camera and patient, to record images which were dimensionally accurate. Digital photographs were saved as RAW files with consistent image compression levels. (Fig: 1)

The protocol given by Bengel W M was followed-

1. The RAW file of the subject was opened by clicking "CTRL +O" in the Adobe Photoshop software.
2. Magnetic Lasso Tool helped to demarcate the zone of interest on the maxillary right central incisor where shade selection is to be performed. The tooth surface reflections were eliminated using the "Magic Wand" tool.
3. The L*a*b values were thus obtained employing the depictions by the histogram on screen.

The smartphone photograph method employed Realme 9 pro smartphone with a Tygo Lightweight long tripod stand. The smartphone camera settings were configured according to the specifications in Table 2. The laptop (Macbook Air 2015) containing the image analysing software Photoscape X and Digital Colorimeter (Fig: 2) was linked to the smartphone.

The following procedure was used for image capturing. The cheek retractor was used for retracting the cheek of the patient for taking the photograph. The distance between the camera and the subject was 17cm, where the longitudinal component of the tripod stand was aligned to the patient's occlusal plane. Additionally, the optical axis was positioned to be perpendicular to the patient's frontal plane. The photographs were captured and saved both in RAW and JPEG formats, where they have consistent image compression standards.

The following procedure was adopted to ascertain the L*a*b values-

1. The images were transferred to Macbook Air and opened using the Photoscape X software.
2. The Digital colorimeter tool was employed to demarcate the zone of interest on the maxillary right central incisor for evaluation of shade.
3. The bottom window shows the L*a*b values of the concerned area.

The data obtained from these three methods were organized into tables and analysed statistically.

Results

The L*a*b values of the subjects were determined using the visual, digital photograph and smartphone photograph method in this study. The data obtained were put through One way ANOVA test since there were more than two groups in the study. And multiple pairwise comparisons were done using Tukey's post-hoc test.

On comparison of L*, a* and b* values obtained between the three groups for the subjects there was a significant difference, the *P* value was 0.0001 ($P<0.01$). The intergroup comparison was performed using ANOVA, which showed significant difference in all parameters (L*, a* and b*) across three estimation methods.

Tukey's post hoc test revealed the following results-

1. For the variable L* there was significant difference noted between digital photograph method and visual method. And there was a significant difference between digital photograph method and smartphone photograph method.
2. For the variable a*, a significant difference was observed between smartphone photograph method and visual method. And there was a significant difference between digital photograph method and smartphone photograph method.
3. For the variable b*, a notable difference was spotted between digital photograph method and visual method. And there was a significant difference between visual method and smartphone photograph method.

Discussion

The growing emphasis on aesthetic dental restorations has fuelled the drive for the quest of a steadfast colour replication process. Achieving successful and consistent colour matching depends upon appropriate shade selection and its precise replication. This necessitates the ability to accurately and consistently measure tooth colour to enhance the overall replication process of a dental material.[6]

In the first method, shade matching for the visual method was done using commercial shade guide (Vita System-3D Master). This is considered to be the most common and easily available method for shade matching.[16] They also boast a higher frequency of usage by dental laboratory technicians, dental assistants and dentists for the proper communication regarding tooth brightness, colour and translucency.[17] The use of shade tab method for the selection of tooth colour completely depends on human eye observation which is considered to be subjective, since it is motivated by age, sex, observer skill, eye strain and environmental light. This can be justified by the findings in this study where, significant difference was seen during intergroup comparison. Although the instruments designed for dental colour matching are very expensive and not readily available to dentists, their popularity and acceptance has shown an immense growth.[18]

The various discrepancies observed in the visual shade matching technique were overcome with the introduction of digital cameras in dentistry, this enabled the performance of an objective analysis by the dental practitioner. The obtained images could be analysed with the help of software wherein the colour parameters of a whole object or even a part of it is recorded, eliminating the problems faced by contact type shade selection instruments.

Colour communication is best carried out using photographic references with shade tabs from shade guide systems, by the use of digital camera. They include the limitations of high cost and steep learning curve to acquire the skill required to handle the equipment to gain optimum results.

The prevalence of high-resolution cameras in the commercially available smartphones have opened up the possibility of using smartphone camera photographs in the dental shade matching process, this empowers wireless communication between laboratory technicians on one side and the dentists on the other side. The smartphone used in this study was Realme 9 pro 5G which had a primary camera of 64 megapixels and focal length of 25.18mm.

In this study the smartphone was configured to automatic mode while the digital camera was configured to manual mode. Significant colour differences observed may be attributed to distinct features such as camera sensor, lenses, white balance and the corresponding software used to convert the RAW file formats. The feature of the smartphone camera where the settings get automatically adjusted to the brightness of the environment is as an unpredictable variable.

The visual method, digital method and the smartphone camera method were all performed on bright daylight by the same operator, but the means to standardize all three methods together have many unexpected variables. Further investigation is required to standardize the experimental setup using smartphone photography.

Conclusion

Taking into account the constraints of this study, the inference obtained showed statistically significant differences among the visual method, digital photograph method and the smartphone photograph method and showed and additional research is necessary to ascertain the best method of shade selection, for a restoration in a patient.

References

[1] Nielsen RK, R. K. The Relative Importance of Social Media for Accessing, Finding, and Engaging with News: An Eight-Country Cross-Media Comparison. *Digit. J.*, No. 2014, 472–489.

[2] Kaplan, A. M.; Haenlein, M. Users of the World, Unite! The Challenges and Opportunities of Social Media. *Business Horizons*, **2010**, *53* (1), 59–68.

[3] Montero, J.; Gómez-Polo, C.; Santos, J. A.; Portillo, M.; Lorenzo, M. C.; Albaladejo, A. Contributions of Dental Colour to the *Physical Attractiveness Stereotype*. *J of Oral Rehabilitation*, **2014**, *41* (10), 768–782.

[4] Labban, N.; Al-Otaibi, H.; Alayed, A.; Alshankiti, K.; Al-Enizy, M. A. Assessment of the Influence of Gender and Skin Color on the Preference of Tooth Shade in Saudi Population. *The Saudi Dental Journal*, **2017**, *29* (3), 102–110. https://doi.org/10.1016/j.sdentj.2017.05.001.

[5] Kim-Pusateri, S.; Brewer, J. D.; Davis, E. L.; Wee, A. G. Reliability and Accuracy of Four Dental Shade-Matching Devices. *The Journal of Prosthetic Dentistry*, **2009**, *101* (3), 193–199.

[6] Rosenstiel , SF, Land MF, Fujimoto J. Contemporary Fixed Prosthodontics-4th Edition; St. Loius Elsevier; pp 712–725.

[7] Paolone, G.; Orsini, G.; Manauta, J.; Devoto, W.; Putignano, A. Composite Shade Guides and Color Matching. *Int. J. Esthet. Dent.*, *9* (2014), 164–182.

[8] Culpepper WD. A Comparative Study of Shade-Matching Procedures. *J Prosthet Dent*, *24* (1970), 166–173.

[9] Geary, J. L.; Kinirons, M. J. Colour Perception of Laboratory-Fired Samples of Body-Coloured Ceramic. *Journal of Dentistry*, 1999, *27* (2), 145–148.

[10] Paul, S.; Peter, A.; Pietrobon, N.; Hämmerle, C. H. F. Visual and Spectrophotometric Shade Analysis of Human Teeth. *J Dent Res*, 2002, *81* (8), 578–582.

[11] Terry, D. A.; Geller, W.; Tric, O.; Anderson, M. J.; Tourville, M.; Kobashigawa, A. ANATOMICAL FORM DEFINES COLOR: FUNCTION, FORM, AND AESTHETICS. *Aesthetic dentistry*, *14* (2002), 59–68.

[12] Shih, P.; Liu, C. Comparative Assessment of Content-Based Face Image Retrieval in Different Color Spaces. *Int. J. Pattern Recognit. Artif. Intell*, *19* (2005), 873–893.

[13] Sampaio, C. S.; Atria, P. J.; Hirata, R.; Jorquera, G. Variability of Color Matching with Different Digital Photography Techniques and a Gray Reference Card. *The Journal of Prosthetic Dentistry*, 2019, *121* (2), 333–339.

[14] Brewer, J. D.; Wee, A.; Seghi, R. Advances in Color Matching. *Dental Clinics of North America*, 2004, *48* (2), 341–358..

[15] Miyajiwala, J. S.; Kheur, M. G.; Patankar, A. H.; Lakha, T. A. Comparison of Photographic and Conventional Methods for Tooth Shade Selection: A Clinical Evaluation. *The Journal of Indian Prosthodontic Society*, 2017, *17* (3).

[16] Borse, S.; Chaware, S. Tooth Shade Analysis and Selection in Prosthodontics: A Systematic Review and Meta-Analysis. *J Indian Prosthodont Soc*, 2020, *20* (2), 131.

[17] Mohammed, A. O.; Mohammed, G. S.; Mathew, M.; Alzarea, B.; Bandela, V. Shade Selection in Esthetic Dentistry: A Review. *Cureus*, 2022.

[18] Tabatabaian, F.; Beyabanaki, E.; Alirezaei, P.; Epakchi, S. Visual and Digital Tooth Shade Selection Methods, Related Effective Factors and Conditions, and Their Accuracy and Precision: A Literature Review. *J Esthet Restor Dent*, 2021, *33* (8), 1084–1104.

TABLES

Table 1: Digital photograph method-camera settings
Fixed shutter speed 1/125s
Automated white balance
Aperture F/ 22
ISO 100
Flash mode – Off
File type – RAW image
Type of metering – matrix

Table 2: Smartphone photograph method-camera settings
Shutter speed- Automatic
Automated white balance
Aperture was set at automatic mode
ISO-Automatic
Flash mode – Off
File type – RAW and JPEG image
Type of metering – matrix

FIGURES

Fig: 1 Determining L*, a* and b* values using Adobe Photoshop CS6 software for digital photographic method

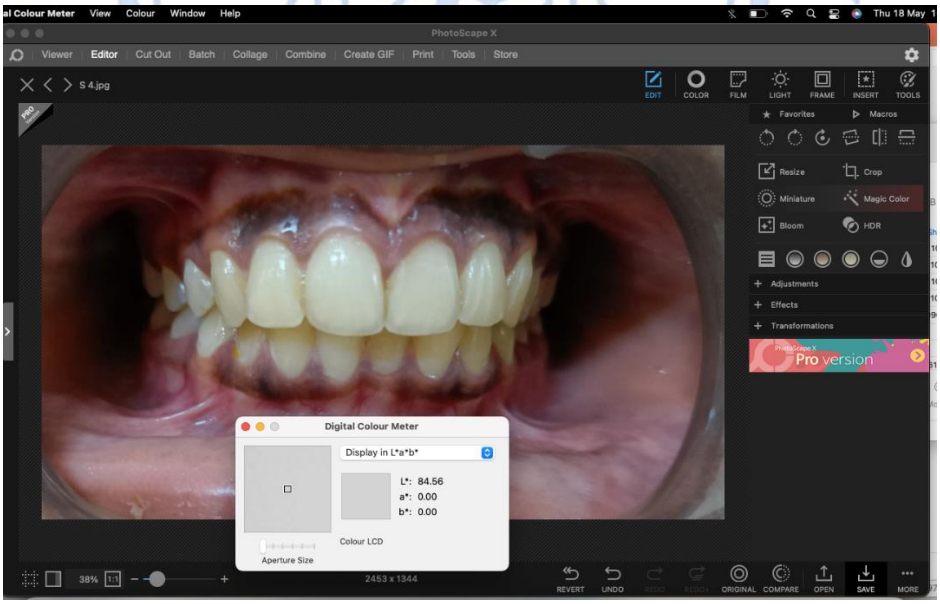

Fig: 2 Determining L*, a* and b* values using Photoscape X and Digital Colour Meter software for smartphone photographic method.