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Using a spectrophotometric study of human gingival color distribution to develop a shade guide

Jhih-Wei Huang [a], *Wen-Cheng Chen* [b], *Ta-Ko Huang* [a], *Po-Sung Fu* [c], *Pei-Ling Lai* [a], *Ching-Fang Tsai* [a], *Chun-Cheng Hung* [a,c,*]

[a] *School of Dentistry, Kaohsiung Medical University, 807 Kaohsiung, Taiwan, ROC*
[b] *Department of Fiber and Composite Materials, College of Engineering, Feng Chia University, Taichung 40724, Taiwan, ROC*
[c] *Department of Dentistry, Kaohsiung Medical University Hospital, Kaohsiung 807, Taiwan*

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ABSTRACT

Objectives: For dental prostheses, color choice is a main concern. The present spectrometric study analyzes healthy gingiva to develop a shade guide for pink aesthetics.
Methods: A reflectance spectrometer and an external light source were set up in a 45/0-degree optical configuration to measure the color of gingiva over the maxillary anterior area. A total of 362 human subjects with healthy gingiva were divided into groups according to sex and age. The Commission Internationale de l'Eclairage L^*, a^*, and b^* (CIELAB) values and differences in color (ΔE) were measured. A two-way analysis of variance (ANOVA) test and cluster analyses were used to analyse the data.
Results: There are significant differences in the gingival color by sex ($\Delta E > 3.7$). The mean CIE L^* value of female gingiva is significantly higher than that of male gingiva ($p < 0.05$). No significant differences were found between age groups. 10 categories for gingival color are established.
Conclusion: The gingival color of females is lighter than that of males. The proposed color classification can be used as a gingival shade guide reference by dental laboratory technicians.

1. Introduction

Aesthetics considerations, including color accuracy, are an important aspect in prosthodontic restorations.[1] Therefore, the study of color is an integral part of aesthetic dentistry.[2] Tooth color matching and duplication have improved with advances in dentistry technology.[3] Several systems that involve visual and instrument inspections have been developed for tooth color matching. These systems allow for the collocation of the proper porcelain or resins necessary for aesthetically pleasing prostheses.[4–7] Dentists can utilise these systems to easily make artificial crowns that match adjacent natural teeth.

Dental prostheses should match both the teeth and gingiva, especially in cases with soft-tissue defects and enlarged edentulous ridges. The gingival part of some fixed prosthetics and many removable prosthetics is very important. However, in contrast to the great advancements in prosthodontic white aesthetics, the characterisation of the gingival portion of prosthetics lags behind.[8] In addition, the application of gingival pink aesthetics in prosthetics has developed slowly and is rarely practised.[7]

Due to the lack of sufficient studies on human gingival color, a standardized gingival shade guide does not currently exist for clinical restoration.[8] A recent study on a commercial gingival shade guide also found that no suitable shade guide is

* *Corresponding author at*: School of Dentistry, College of Dental Medicine, Kaohsiung Medical University, Department of Prosthodontics, Kaohsiung Medical University Hospital, No. 100 Tzyou 1st Rd., Kaohsiung City 807, Taiwan. Tel.: +886 7 3804437; fax: +886 7 3804437.
E-mail addresses: wencchen@fcu.edu.tw (W.-C. Chen), yuchali@ms21.hinet.net (C.-C. Hung).
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available for matching the color of prostheses to human intraoral soft tissues.[9] Without a suitable shade guide with a sufficient range of gingival colors, it is difficult to make aesthetically pleasing prosthetics for patients. A shade guide should be based on the representative colors of natural intraoral human soft tissue.[10]

Even amongst the few and deficient color studies that have been published, measurement agreement is rare. Accordingly, no guidelines exist for deciding what colors match the gingiva of patients, especially for the elderly. In addition, in these studies, the color of healthy gingiva was usually described as being only either pale pink, coral pink, or darker.[11] A review of past studies of gingival color revealed that in addition to measurement problems, most investigations involved no controlled or randomized design, had low levels of evidence, and used small sample sizes.[7] Many of these studies excluded visual color measurements due to low accuracy. Unlike teeth, gingiva is difficult to measure in vivo due to their elasticity and irregular morphology. In the present study, the findings of some recent studies on spectrometric oral color measurement are considered and a modified, controlled design that includes a sample size larger than those used in many previous studies is used.[12–16]

The Commission Internationale de l'Eclairage L^*, a^*, and b^* (CIELAB) system allows for quantitative comparisons of color. Important clinical advances have been made since authors began reporting color distribution in CIELAB color coordinates.[17] Color differences (ΔE) can be calculated using[18]: $\Delta E = [(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2]^{1/2}$.

In vivo studies have demonstrated that a perceptible color difference generally falls in the range of 1–2 ΔE units, with a difference of less than 1 unit being imperceptible.[17] Other studies have found that ΔE values greater than 3.7 units indicate that mismatching might occur during visual color measuring, and that ΔE values greater than 6.8 units indicate poor color matching.[12]

Few in-depth studies have been conducted on the color of gingiva. The major purpose of the present study is to investigate the color distribution of gingiva in a Taiwanese population by analyzing the CIELAB values and calculating the ΔE values for various sex and age groups. The gingival color differences between sex and age groups are examined. The collected color data are used in conjunction with a clinical survey to develop a gingival color classification system.

2. Methods and materials

2.1. *Spectrometric set-up*

A miniature fibre optic spectrometer (USB 2000, Ocean Optics, Dunedin, USA) was used with a fibre optic lamp that was shone through a monochromatic light (λ = 400–720 nm) grating filter via a transmission optical fibre (400 μm read fibre UV/VIS, Ocean Optics, USA). A receiving optical fibre with the same specifications was used for the sensor. The fibres were set up in an optical configuration with a 0-degree observation fibre and 45-degree illumination fibre for the measurement of color. The tips of the optical fibres were standardized to 20 mm from the gingiva with a measurement

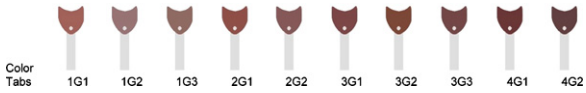

Fig. 1 – Diagram of the design of gingival color-matching pads based on Table 4 calculations.

aperture size of 3 mm. For this custom device, the measurement pathway between the object and the tips of the optical fibres was covered by black elastic materials to provide a protective sheath against the edge-loss effect (Figs. 1 and 2).

For all color measurements in this study, the spectral reflectance was obtained from measurements from 250 to 800 nm with a 2-nm interval and converted to CIELAB values using OOIIrrad-C software (Ocean Optics, USA).

The color measurement device configuration was evaluated for stability and validity *in vitro*. The stability of the light source was evaluated prior to color measurement. A smooth, homogenous white tile (standard white, SW) was used as the standard specimen. A 10-min warm-up was used to ensure the stability of the machine. The warm-up time period was based on the results of a prior study. The validity of the color measurement instrument configuration was tested with an integrating sphere by comparing the data from measurement of SW and Munsell color tabs. The Munsell color system is suitable for color matching.[19] Based on studies involving the measurement of gingival color and color matching to the gingiva of fifteen subjects with Munsell color tabs

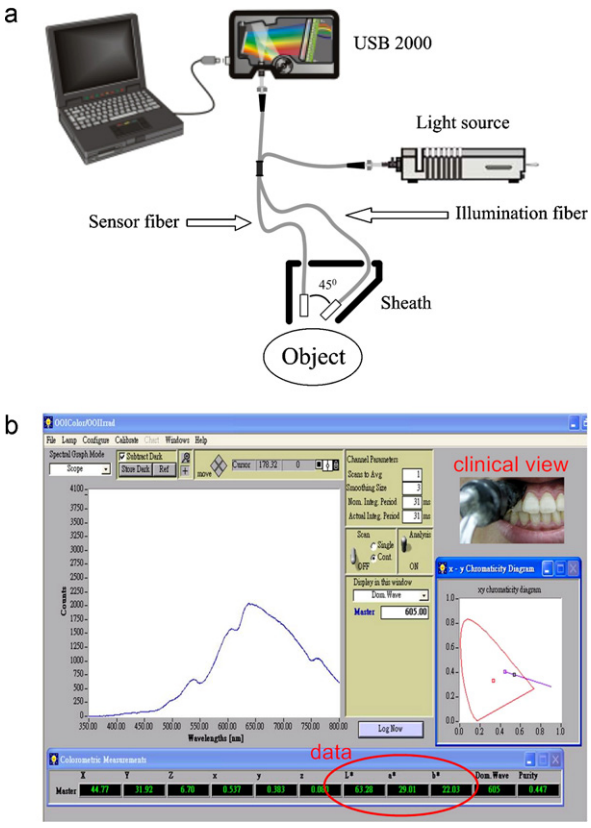

Fig. 2 – Diagram of measurement set up (a) and the clinical image to demonstrate the technique (b).