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A photographic method to measure the colour characteristics of healthy gingiva

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Abstract: *Background:* Colour of healthy gingiva is mostly determined by subjective visual observation. The introduction of digital imaging and diagnostic tools to evaluate colour makes it feasible to measure gingival colour more objectively. *Methods:* A study was designed to obtain reproducible photographs of anterior maxillary gingiva of a study group of 26 dental hygienist students with a professional attitude for healthy gingiva. Gingival health was evaluated clinically by probing marginal portions of gingiva. No bleeding on probing was considered the gold standard for health. For the colour measurements on the photographs adobe photoshop software was used and colour was expressed in the Cie $L^*a^*b^*$ colour system. Gingival selections were extracted from the photographs and brightness (L^*), redness (a^*) and yellowness (b^*) were calculated. *Results:* The L^* colour characteristic varied from 72 to 78 (average 76), The a^* characteristic from 12 to 23 (average 20) and the b^* characteristic from 13 to 21 (average 16). *Conclusion:*The findings of this study suggest that the colour characteristics of normal gingiva can vary considerably and still be healthy. Objective digital measurements of gingival colour characteristics may become a valuable, reproducible and practicable evaluation method of gingival health. This photographic study has explored measurement procedures towards this aim.

Key words: CIE $L^*a^*b^*$ characteristics; gingival colour; healthy gingiva; measurements

Introduction

The colour of healthy gingiva is described as pale pink or coral pink and darker in people with darker complexions (1). However, determination of gingival colour has been done mostly by subjective visual observation (1–3).

Electronical gingival colour measurement could be done by treating colour in a quantitative manner by measuring the gingival reflectance spectrum. Electronical instruments, like a spectrophotometer (4) or colorimeter (5) can obtain such data. As colour measurements with a colorimeter are mostly invasive and spectrophotometer measurements generate edge-loss effects (6), an alternative measuring procedure on photographs obtained with a digital camera was chosen. Measuring on digital photographs ensures reproducible and non-contact colour measurement (7).

The output of the colour measurements can be classified in several ways. The most common systems for describing colour are the Munsell System (8) and the International Commission on Illumination (CIE) $L^*a^*b^*$ system (9). Munsell defined colour by three parameters of colour, Hue, Value and Chroma. Hue describes the dominant colour of an object, for example, red, green or blue. Value is the lightness or darkness of colour. Chroma represents the degree of saturation of a particular Hue. An important step forward in a clinical sense was made when authors reported colour distribution in the CIE $L^*a^*b^*$ colour co-ordinates (10). The CIE $L^*a^*b^*$ system describes colour with three colour characteristics L^*, a^* and b^*. The L^* characteristic lies on an axis that goes from white to black. The L^* axis stands perpendicular to the horizontal axis a^* that runs from green to red and perpendicular to b^* on the vertical axis that runs from yellow to blue. In principal, these colour values, obtained from the reflectance spectrum, provide a numerical description of the colour position in a three-dimensional colour space. The CIE $L^*a^*b^*$ colour characteristics are commonly used in dentistry to define the colour of teeth (7).

The aim of this study was to describe a photographic method to obtain objective and precise data on colour characteristics of healthy gingiva using a simple digital camera set-up and the CIE $L^*a^*b^*$ calculation technique.

Methods

Study group

A group of 26 dental hygienists participated in the study. The average age of the females was 22.1 (SD = 4.1). Informed consent was obtained from the study participants before the commencement of clinical examination and photograph.

Assessment of gingival health

Presence of health in the marginal portion of gingiva was recorded by means of probing assessments (11). The teeth and gingiva were dried and observed under adequate light. A mouth mirror and probe (Hu–Friedy, Chicago, IL, USA; PQW 15) were used. The probe was moved along the soft tissue wall near the entrance to the gingival sulcus to evaluate bleeding. Absence of bleeding on probing to the base of the pocket tends to be the gold standard for gingival health in epidemiological studies (12, 13). Four gingival surfaces (distal, buccal, mesial and lingual) were examined systematically for each anterior maxillary tooth. Gingiva of the participants of the study did not exhibit bleeding on probing.

Camera

Gingival colour information was obtained from photographs of the gingiva around the maxillary anterior teeth. A digital camera with a zoom lens of F1.8 (Camedia C-5050 ZOOM, Olympus, Tokyo, Japan) was used. A macro lens with $F = 40$ cm (Olympus) was mounted on the camera together with a macro light reflector. The camera with macro lens and reflector were mounted on a horizontal aluminum bar that rested on a tripod. At the other site of the bar an aluminum-positioning arch for head fixation was attached. The forehead rested against the aluminum arch and the maxillary anterior teeth were positioned on a bite-block. The distance of the lens towards the maxillary anterior teeth was approximately 13.5 cm depending on the anatomy and the position of the teeth. The camera had standard settings and a white colour ceramic reference standard was used for comparison of the found data. The photographs were obtained in Tiff format. Photograph size was 2560×1920 pixels/in. ISO was 100 and the white balance was 1. The shutter time was 1/60 s. F was 8.0. All photographs were filed with the following parameters:

1. Photograph size: Width at 2560 and height at 900 pixels/in.
2. Resolution: set at 300 pixels/in.
3. Colour mode: RGB colour and 8 bit.
4. Background contents: white.
5. Colour profile: working RGB: sRGB IEC6 1966–2.1.
6. Pixel aspect ratio: square.

Ceramic white reference standard

Underneath the bite-block a ceramic white reference standard was mounted. The reference standard was measured for calculation of the real values of the Lab characteristics of the gingiva (14). The CIE $L^*a^*b^*$ colour characteristics of a ceramic white reference standard are ideally 100, 0 and 0.

Figure 1 shows positioning device for standardized mouth photography and the obtained photograph of the anterior maxillary teeth and gingival regions.

Measurement colour characteristics

ADOBE PHOTOSHOP CS2 version 9.0 was used for the measurements of the colour characteristics (15). Descriptions of the reproducibility of the measurements with the photographic technique were published (7). PHOTOSHOP calculates the Lab characteristics for the reference standard as 256,128,128.

Gingival selection and extraction

A gingival selection was made on each of the 26 photographs of the anterior maxillary regions and extracted from the photograph. The procedure was as follows:

1 A square area around the teeth and gingival regions was cropped. The cropped area was enlarged by: view – fit on screen.

2 Gingival selection was defined with the magnetic lasso and dragged with the move tool to a new file (Fig. 2).

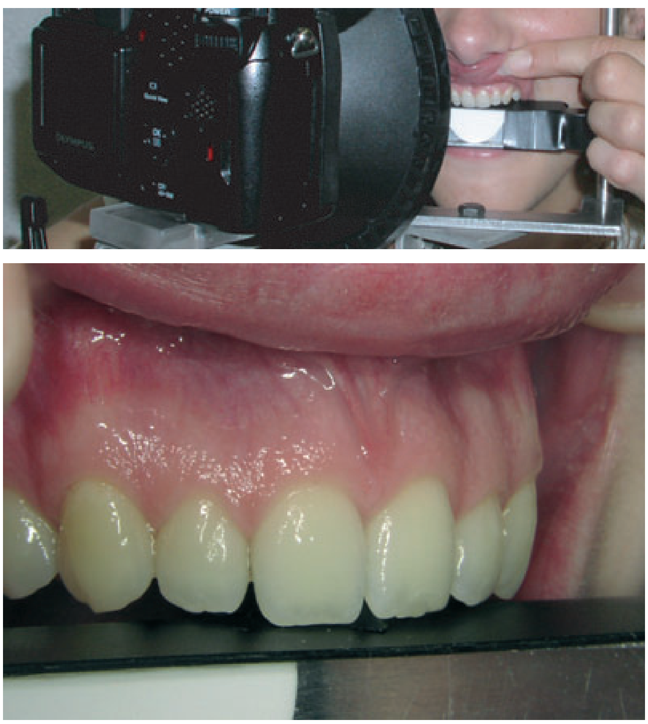

Fig. 1. Top: view of camera set-up for photographs of maxillary anterior gingiva. Bottom: the obtained photograph for the measurements of the colour characteristics of the gingiva.

Fig. 2. Top: gingival selection bordered by the dotted line and drawn with the magnetic lasso. The dotted line follows closely the gingival region around the teeth. Bottom: extraction of gingival selection for the measurements of the colour characteristics.

Colour measurements

For the colour measurements the magic wand tool was clicked at a site in the gingival selection without reflection and pigmentation. Consequently all the sites without reflection and pigmentation were included in the measurements. The histograms show the mean colour values for each of the Lab characteristics (Fig. 3).

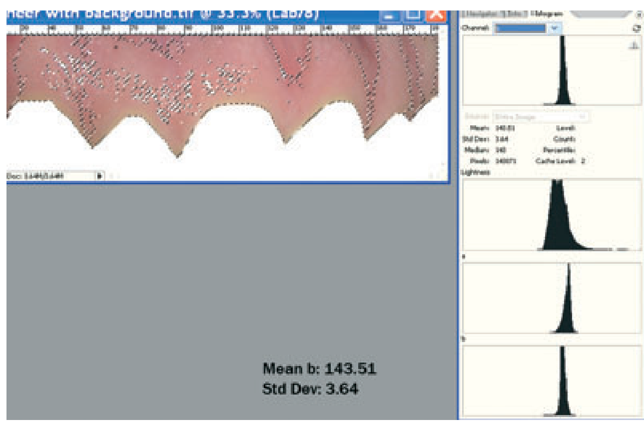

Fig. 3. Areas in gingival selection with reflection (dotted) are excluded from the colour measurements because they give no colour information. At the right: histograms with statistical data of the measured Lab colour characteristics.

For the measurement of the Lab characteristics of the white reference standard, the magnetic lasso defined the bloc area and Lab histograms were obtained as described for gingiva.

Statistics

To obtain true gingival colour values, the measured Lab values had to be corrected by means of the true values of the white standard being for $L = 256$, for $a = 128$ and for $b = 128$ (14). True gingival value for L was calculated as $L = 256$/measured value × 192. For $a = 128$/measured value × 149 and for $b = 128$/measured value × 148 (16).

Lab colour values vary for all three characteristics between 0 and 256 (8 bits) (15). For the Cie $L^*a^*b^*$ system the colour values are for L^* = black (0) – white (100), for a^* = green (−90) – red (+70) and for b^* = blue (−80) – yellow (+100) (7). The conversion of Lab values into Cie $L^*a^*b^*$ values are thus as follows: $L^* = L$ value/256 × 100; $a^* = a$ value/256 × 160–90 and $b^* = b$ value/256 × 180–80.

Results

Gingival colour characteristics of health

Table 1 shows the measurements of the gingival colour characteristics of the 26 dental hygienists and Table 2 the highest, lowest and the mean colour values and SD of the Lab and the Cie $L^*a^*b^*$ colour values.

Discussion

Photometric digital studies have been focused on tooth colour (7, 17, 18). However, objective photographic data on gingival colour are not readily available. Jones (19) developed an apparatus that was suitable for measuring gingival colour in terms of reflectance. Gingival colour ran in reflectance from 17% to 45% of the magnesium oxide standard and healthy gingival colour of the participants of the study did not vary with sex and age. Gingival colour was lighter in participants with lighter complexions. Although clinically healthy gingiva varies with anatomical, physiological and other characteristics, gingival col-

Table 1. **Measurements of colour characteristics of healthy gingiva**

	Ceramic white reference standard (lab values)			Gingival colour characteristics (lab values)			True gingival colour characteristics (lab values)			True gingival colour characteristics (CIE $L^*a^*b^*$ values)		
Dental hygienist	L	a	b	L	a	b	L	a	b	L^*	a^*	b^*
	255	127	131									
1				195	153	147	196	152	144	77	23	15
2				193	151	148	194	152	145	76	23	16
3				187	140	149	188	141	146	73	12	17
4				199	152	150	200	153	147	78	23	18
5				184	150	148	185	151	145	72	22	16
6				198	147	147	199	148	144	78	19	15
7				193	151	146	194	152	143	76	23	14
8				192	149	148	193	150	145	75	21	16
9				190	150	150	191	151	147	75	22	18
10				198	142	145	199	143	142	78	14	13
11				197	151	147	198	152	144	77	23	15
12				188	152	146	189	153	143	74	23	14
13				186	151	145	187	152	142	73	23	13
14				195	145	145	196	146	142	77	17	13
15				199	141	149	200	142	146	78	13	17
16				198	145	151	199	146	148	78	17	19
17				197	149	153	198	150	150	77	21	21
18				196	149	150	197	150	147	77	21	18
19				196	149	153	197	150	150	77	21	21
20				188	152	146	189	153	143	74	23	14
21				188	146	148	189	147	145	74	18	16
22				191	150	146	192	151	143	75	22	14
23				186	148	145	187	149	142	73	20	13
24				199	145	147	200	146	144	78	17	15
25				193	151	148	194	152	145	76	23	16
26				197	151	147	198	152	144	77	23	15

Table 2. **The highest, the lowest and the mean of colour characteristics and SD**

Gingival colour characteristic	Highest	Lowest	Mean	SD
L	200	185	194	5
a	153	141	149	5
b	150	142	145	2
L^*	78	72	76	2
a^*	23	12	20	5
b^*	21	13	16	2

our forms an objective photographic baseline for a contrast in the recognition of inflammation (19). Until recently, analysis of colour slides remained an attractive technique to achieve this goal. However, limitations were based on the photographic procedures such as the control of lighting, film emulsion and film processing. These limitations are now overcome with the availability of digital technology. It is thus surprising that so little digital colour information on gingival health is obtained in contrast to extensive digital use in other dental fields. Nevertheless, objective data on colour characteristics of healthy gingiva would also create a step-up for gingival diagnostics.

In this study an easily manipulated, inexpensive, reliable, digital camera obtained photographs with rigid photographic standards. Routine digital measurements on the photographs produced the gingival colour characteristics $L^*a^*b^*$. It appears that healthy colour is not simple pale pink or coral pink but varies considerably when digitally measured in the colour characteristics $L^*a^*b^*$. In the dental hygienist study, the brightness colour characteristic L^* varied from 72 to 78; the redness characteristic a^* from 12 to 23 and the yellowness characteristic b^* from 13 to 21. The findings of this objective clinical study suggest that the colour of normal gingiva can vary considerably and still be healthy.

Quantitative analysis of colour characteristics on digital images may become a valuable, objective, practicable and inexpensive evaluation procedure of gingival health. This study centered on exploring photographic and measurement procedures towards this aim.

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