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Optical effects of different colors of artificial gingiva on ceramic crowns

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ABSTRACT

Objectives: The interaction between gingival color and the shade of ceramic restorations has never been fully studied. The purpose of this study is to investigate the optical effects of altering artificial gingival color on the ceramic crown shade in the cervical area.
Methods: Thirty-one all-ceramic crowns of different shades were used in this study with six different artificial gingival colors. Using a spectrophotometer (Crystaleye® Olympus, Japan), we measured the shade of crowns in cervical areas with each of six different artificial gingiva. The crown color measured in the presence of pink artificial gingiva (control) was compared with the crown color with five other artificial gingiva. color difference values ΔE^* were calculated and compared between the control group and test groups and the correlation of the artificial gingival color with the crown color was also assessed.
Results: Significant differences were found in the mean L^* and a^* values of all-ceramic crowns at the cervical regions in all six gingival color groups ($p < 0.001$) and significant Pearson correlations were also found for the mean L^* ($r = 0.987$, $p < 0.001$) and a^* ($r = 0.856$, $p = 0.03$) values between the artificial gingiva and the ceramic crowns. The mean ΔE^* values between the control group and each of the five other gingival groups were all significantly larger than the clinical perceptual threshold of ΔE^* 1.6 ($p < 0.001$).
Conclusions: Different colors of artificial gingiva generated clinically detectable shade differences in the cervical region of ceramic crowns.

1. Introduction

In the last few decades, ceramic materials for restorative dentistry have evolved significantly, and aesthetic restorations, such as all-ceramic crowns and veneers, are routinely used in practice. As the media and patients pay more attention to aesthetics, clinicians and ceramists are facing increasing demands and expectations for accurate color matching and reproduction.[1] However, current shade communication in dentistry is affected by many factors,[2–5] resulting in frequent errors both from the dentist in shade selection and from the ceramist in shade replication. One factor that compromises shade matching is the lack of attention to the optical effects of the surrounding oral cavity and soft tissues by both dentists and ceramists. The oral cavity and especially the color of the

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gingival tissues are important for shade match and replication because of the contrast between the red-violet color of the gingiva and the tooth. Owing to the position of red-violet coloration within the spectrum, the presence of these colors in the gingiva makes the perception of red-violet difficult in neighbouring structures such as in tooth, creating the impression that green-yellow colors exist in vital teeth. Consequently, this error in perception may lead to selecting an inaccurate shade and lead to a disappointing outcome.[6–8]

In view of the fact that the reddish gingiva is influential for exact determination of the shade of the tooth because of the contrasting effects, some measures have been taken to neutralize the influence of the color contrast of the gingiva. For clinical shade matching, a gingival indicator was designed by a dental company to take into account the contrasting effects of the patients' gingiva when determining proper shade.[9,10] Placing the shade tabs in the selected gingiva indicator for shade evaluation minimizes assessment errors and helps to reveal the color interplay of tooth to gum and the effect of the resulting contrast. In the dental lab, artificial gingiva can be attached onto the dental cast models while the ceramists replicate or double-check the color of the ceramic restorations. The artificial gingiva helps to simulate the oral environment and avoid greyness or reduced value in the final restoration.

Although the gingival indicators stated above are available in light, medium, and dark tissue shades, they still do not sufficiently represent the full spectrum of color found in human gingival tissue. Moreover, the gingival indicator's potential influence on the color measurements still needs further study. In addition, when a dental technician is fabricating the ceramic restorations, limited shade options are available for the artificial gingiva used for soft tissue models. Many dental technicians use no or only one color of artificial gingiva on the model when replicating a patients' tooth color. Disregard for the dento-gingival optical relationship creates the potential for inaccurate shade reproduction.

The characterization of healthy gingival color ranges from pale pink[11] and pink[12] to dark red[13] or purple.[14] In addition, a number of influences on gingival and mucosal pigmentation have also been reported: gender and age, location (left, right, mandibular, or maxillary), skin type, melanin content, as well as changes related to hormones, blood pressure, and gingival inflammation.[15,16] External sources of gingival discoloration may include the type and location of the restoration as well as smoking.[17–19] It seems that the color range of gingival tissues is even broader than the tooth color range. The lightness and hue range are wider and the chroma range is narrower for natural teeth.[20] Therefore, it is reasonable to postulate that having only one shade of artificial gingiva cannot be a universal solution to compensate for the optical effect of gingiva on tooth color. Furthermore according to the paper (in print. Wang J, Lin J, Seliger A, Gil M, DaSlva, J, Nagai S: color effects of gingiva on ceramic regions of all-ceramic crowns: *J Esthet Rest Dent*), a significant amount of color difference is seen in the cervical area of a crown with and without pink artificial gingiva. Therefore the next step in understanding the influence of gingival color, is to know the impact of a variety of gingival colors on ceramic crowns.

The purpose of this study was to investigate the optical effects of different color artificial gingiva on ceramic crown color. Six representatives of marginal gingival colors were defined light pink, pink, red, orange, light purple and dark brown, based on previous literature.[11–14] This *in vitro* study has been designed to address the following specific aims: (1) investigating the difference in optical properties of the cervical regions of all-ceramic crowns in the presence of six different shades of artificial gingiva and (2) analyzing the correlation of the artificial gingival color and the crown color. The null hypothesis was that there is no significant difference in color values of the ceramic crowns at cervical regions when different color artificial gingiva are attached to the crowns, and the color of the artificial gingiva is not correlated to the color of the ceramic crown.

2. Material and methods

2.1. *Sample preparation*

Thirty-one all-ceramic crowns fabricated for the maxillary central incisors were included in this study. All crowns were fabricated from zirconia cores in different shades with layered porcelain (CZR, Katana; Noritake, Japan) for tooth #8 or #9. The clinical procedures were performed based on the standards of Harvard Dental Center, and all-ceramic crowns were fabricated at the same dental laboratory (Cusp Dental Research, Lynn, MA). Each crown was placed over an abutment made of tooth-shade die material and inserted into a typodont which was mounted in a black inspection box (Crystaleye; Olympus Co., Tokyo, Japan) that simulates the dark background of the oral cavity. Six artificial gingiva colors (pale pink, pink, red, orange, light purple and dark brown, Fig. 1) were attached sequentially around the cervical area of crown in order to simulate the real dento-gingival relationship. Six artificial gingival colors were determined using our database of gingival color from 215 patients obtained by a use of dental spectrophotometer. The color space was divided into 6 groups, and one representative color from each of 6 groups was determined and utilized for this study. By trial and error, 6 artificial silicon samples were fabricated to match those representative colors. The most commonly used artificial gingiva attached to the typodont (Nisshin Co, Tokyo, Japan) was named ''pink'' and also used as one of six colors.

These 6 artificial gingiva specimens were fabricated using maxillofacial silicone (Platinum silicone #VST50, Factor II, Inc.) and internal stain (Intrinsic Silicone Coloration System, Factor II) based on manufacture's instructions. Anatomy of soft tissue was replicated with original typodont (Nissin Dental Products INC, Japan). The margin of the artificial gingiva was kept in tight contact with the surface of crowns.

2.2. *Color measurements*

A dental spectrophotometer (Crystaleye® Olympus, Japan) was used for the color measurements. This spectrophotometer employs 7 LEDs (light emitting diodes) as an illumination source with 45/0-degree geometry. The instrument was