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RESEARCH AND EDUCATION

Influence of tongue position on the determination of tooth shade

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ABSTRACT

Statement of problem. Dentists frequently use electronic devices to determine tooth color. However, neither the instructions for these devices nor the accompanying brochures refer to the environmental conditions required at the point of measurement.

Purpose. The purpose of this multicenter prospective clinical study was to reveal whether a change in the oral background influences tooth color determination.

Material and methods. Students (N=42) at the dental clinic in Berlin, Leipzig, Greifswald and Olomouc (women n=27, men n=15) participated in this study. It was their first contact with the spectral photometer (Easyshade Advance 4.0; VITA Zahnfabrik). After a short introduction on how to use the device, the students made 1-point measurements on the same patient on the maxillary central incisor. In the first measurement, the patient's mouth was open, and the palatal surface uncovered. In the second measurement, the patient's mouth was closed slightly, and the tongue pressed on the lingual surface of the maxillary central incisor. The mean ±SD and the 95% confidence interval (95 % CI) were calculated using the Student *t* test for each test series (α=.05).

Results. Statistical evaluation of the 2 measurements revealed changes in the L*a*b* values with a mean L*=0.204, a*=-0.351, and b*=0.02; a median of 0.4, -0.3, and -0.1, respectively; a ±SD of 2.37, 0.64, and 0.89, respectively; and 95% CIs of L*=-0.476 to 0.884, a*=-0.531 to -0.702, and b*=-0.23 to 0.52, respectively. These differences were not statistically significant (*P*>.05). The measurements of L*, a*, and b* with and without tongue coverage of the lingual surfaces of the maxillary teeth did not show any statistically significant differences (*P*=.663).

Conclusions. The results demonstrate that the position of the tongue does not influence measurement accuracy during the application of the Easyshade Advance device. (J Prosthet Dent 2017;117:289-293)

Esthetics and tooth color play important roles in dentistry. The selection of the patient's tooth color is a significant treatment step. However, determining tooth color poses a challenge for both dental practitioners and dental technicians. In addition, the costs for color correction can be substantial.[1] A number of visual and electronic tools for tooth color matching are available to dental practitioners, and these tools can improve communication with the dental laboratory.

The methods most commonly used for shade selection and visual color determination in European dental schools[2] are the Vita Classical shade guide (VITA Zahnfabrik) and the Vitapan 3D-Master shade guide (VITA Zahnfabrik). Only a minority of students have been introduced to digital shade determination.[2] In the United States, the majority of dental practitioners in private offices use the Vita Classical shade guide (59.8%, VITA Zahnfabrik) and the Vita 3-D Master shade guide (34.4%, VITA Zahnfabrik).[3] In the study by Wee et al,[3] only 1 dentist used an electronic instrument (Vita Easyshade Compact; VITA Zahnfabrik), and another used digital images when communicating with the dental laboratory.

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Clinical Implications

In order for digital tools to reliably determine shade, environmental parameters should have no influence on color recordings.

Currently, visual tooth color determination is regarded as the standard method. Its principle rests on the Munsell color system. The tooth selected for shade matching is compared with a sample of the color scale, which serves as the reference under neutral light conditions. Multiple color scale reference systems represent the color spectrum of natural teeth. All of the currently used systems exhibit different levels of accuracy and characteristics. One of the preconditions for adequate matching is that experienced individuals under reproducible conditions (that is lighting and viewing distance) visually determine tooth color. Thus, a key issue addressed by Wee et al[3] was the focus on lighting conditions in private dental practices, which can lead to differences in determination. The conclusion of their study was that the use of ambient light in dental offices is not sufficient to ensure accurate color differentiation.

The consequences and the effects of different lighting conditions were also studied by Kröger et al.[4] In their investigation, visual color differentiation was performed under daylight, halogen light, and fluorescent light (5000 K and nonspecific ceiling light).[4] They found that the impact of different lighting conditions on color differentiation could be mediated by the use of electronic devices.

Clinical studies have demonstrated that a subjective color determination can in fact be learned.[1-7,27] In a curriculum for tooth color determination, the effect of this training on dental students depended on their sex and age.[5]

The results of the determination of tooth color using the Vita Classical System and the 3D-Master-System are different. The 3D-Master-System requires a determination of color in 3 consecutive steps: lightness (5 categories), chroma (3 categories), and hue (3 categories) with 26 defined samples.[5-7] Through the determination of the lightness value in the first level, up to 60% of the incorrect assessments are eliminated. The second and third steps, determination of chroma and hue, further decrease color-matching errors. All of these measurements result in color values with a compliance of almost 70%.[11,12]

In an effort to minimize potential influence factors in the visual shade-taking process, electronic color measuring devices have been developed. These devices can be divided into 3 groups: spectrophotometers, colorimeters, and digital cameras.

When tested for accuracy and precision for tooth color determination,[13-17] the systems differed in measurement geometry, sensitivity in handling, configuration, robustness, construction, and price.[13] The digital spectrophotometer Vita Easyshade (VITA Zahnfabrik) has commonly been used for tooth color determination in clinical studies.[18-24]

An advantage of the digital systems is good repeatability, particularly compared with manual color determination.[25-28] Light reflections of the tooth are analyzed by electronic measurement devices (emission spectrum), and color values allow for reproducible color comparisons by overlapping the remittance spectra and lighting. The spectrophotometers analyze color in the physical wavelength range of 400 to 700 nm using the light-independent measuring procedure of the reflection.[28] The high reproducibility basis of the color coordinates are not influenced by modified environmental conditions.[20,21] In contrast, the results of the visual, subjective color determination are adversely affected by environmental factors.[7] Apart from the consideration of physical factors such as the reflection of surrounding colors, chameleon effect of surrounding restorations, color temperature of the viewing light,[3,4] and surface condition of the tooth being assessed, the biological-physiological effects such as the arrangement of the color pigments within the cones of the retina are substantially responsible for color perception and differentiation.[29]

Furthermore, causes such as deficits in color perception (red-green color visual impairments, cataracts, and sight defects) negatively influence the outcome of subjective color perception.[29] Accordingly, the variability of the user's subjective color perception, the insufficient standardization of lighting, and the influence of environmental parameters lead to a considerable variance in the field of subjective visual shade selection.[8-10] The use of digital systems reduces the variance of the results, thus increasing the reliability of determining the tooth color. In addition to these advantages, the color of dental restorations may be evaluated during their fabrication process using digital colorimeters, a valuable instrument for minimizing risks and enhancing quality control in the dental laboratory.[4,30]

However, data and guidelines are still insufficient to ensure the reproducibility of digital color determinations under intraoral conditions. The hypothesis of this study was that the coverage by the tongue does not change the L*a*b* values of a natural reference tooth.

MATERIAL AND METHODS

Dental students (N=42; 27 women and 15 men) in the preclinical phase at the Universities of Berlin, Greifswald, and Leipzig in Germany and Olomouc in Czech Republic participated in this multicenter prospective study. The students were voluntarily participants who were

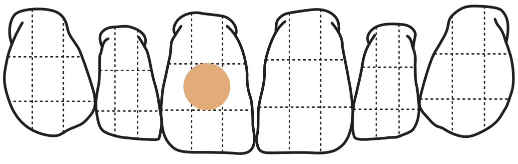

Figure 1. Measurement procedure using applied spectral photometer (Vita Easyshade Advance 4.0; VITA Zahnfabrik).

attending the preclinical course "Learning tooth color differentiation," and this was their first contact with an electronic measuring device used for tooth color determination. Additional volunteers were not available for this research. The Ethical Committee of the University of Greifswald (Ref. BB 43-16) approved the study protocol. The students assumed pseudonyms for the purpose of data generation once they had agreed to participate in the research project.

A spectral photometer (Vita Easyshade Advance 4.0; VITA Zahnfabrik) was used for objective color determination in this study. This device is a portable system for clinical tooth color determination and has been available since 2008. The device consists of 3 main components: a light source, a measuring device that receives the reflecting light of the object, and a spectrometer. The spectrometer measures the intensity of the reflecting light in the form of wavelengths in a range of 400 to 700 nm. The subsequent analysis using the International Commission on Illumination Lab (CIELab) system serves as the basis for the analysis of reflected light.[32] On the vertical axis, it represents relative lightness and darkness. The 2 horizontal axes a and b indicate the amount of green/red and blue/yellow measured, respectively. In the CIELab color space, L* is the index for the brightness of an object, a* stands for green or red tones, and b* represents the index for blue or yellow.

After being given a short introduction to the device, the students made 2 different single-point measurements of the maxillary right central incisor on the same test person. A device-specific polyethylene foil (VITA Zahnfabrik) protected the tip of the intraoral spectrometer before each calibration procedure. Likewise, the initial measurement was made in the middle third of the labial dental surface of the central incisor with the test person's mouth slightly opened and the tongue retracted.

The second measurement was made at the same measuring point, also with the test person's mouth slightly opened and with the tongue pressed to the oral surface of the maxillary right central incisor (Fig. 1). Both of the results were recorded and statistically evaluated. The analysis of the results contains the distance (ΔE, [1]) to the chosen pattern in the CIELab color space for each participant. The distance between 2 colors within the color space was calculated as the Euclidian distance according to International Standards Organization (ISO) standard 12647 and ISO standard 13655. The results were added, and the average, median, and 95% confidence intervals (95% CI) were calculated for both groups, as follows:

$$\Delta E = \sqrt{(L1 - L2)^2 + (a1 - a2)^2 + (b1 - b2)^2}$$

Statistical software (IBM SPSS v19.0; IBM Corp) was used to evaluate the results. Because of the small group of participants, the mean ±SD and the 95% CI were calculated using the Student t test for each test series (α=.05).

Table 1. Comparison (ΔE) of two measurements[a]

Dimension	Mean	Median	SD	95% CI
L*	0.204	0.4	±2.37	-0.476 to 0.884
a*	-0.351	0.3	±0.64	-0.531 to -0.702
b*	0.02	-0.1	±0.89	-0.23 to 0.52

[a]See Figure 2.

RESULTS

When the 2 measurements were compared (Table 1), the statistical evaluation revealed slight changes (ΔE) in the CIELab, with a mean L*=0.204, a*=-0.351, and b*=0.02. The results showed a median ±SD L*=0.4 ±2.37, a*=-0.3 ±0.64, and b*=-0.1 ±0.89, and 95% CIs of L*=-0.476 to 0.884, a*=-0.531 to -0.702, and b*=-0.23 to 0.52 (Fig. 2). No indications of statistical differences were found in the measurements of CIELab related to the coverage of the oral surface by the patient's tongue (P=.663) (Fig. 3). Differences in the mean values of both of the groups were not great enough to reject the possibility that the difference was due to random sampling variability.

DISCUSSION

This study presents the preliminary results of 2 intraoral methods of measurement with a spectrophotometer (Vita Easyshade Advance 4.0; VITA Zahnfabrik). One measurement was made at the labial surface with an uncovered lingual surface of the maxillary central incisor; a second measurement was made while the test person pressed the tongue to the lingual surface of the central incisor. Only small differences in CIELab were detected, and no significant differences were found in these measured values (P>.05). The post hoc analysis with the current data showed a statistical power of .07. To calculate a priori the required sample size, the effect size is needed. This is the first published study of this subject with the additional aim of determining the effect size, which is a prerequisite for the calculation of the sample size. Based on the results of the present study, we were able to calculate an effect size of .064.

To achieve sufficient results with α=.05 and a statistical power of .8, a population size of at least N=1922 is

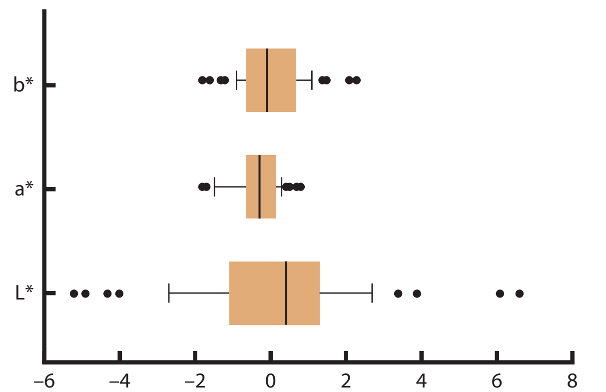

Figure 2. Deviation (ΔE) of L*, a*, and b* of 2 measurements with and without tongue coverage.

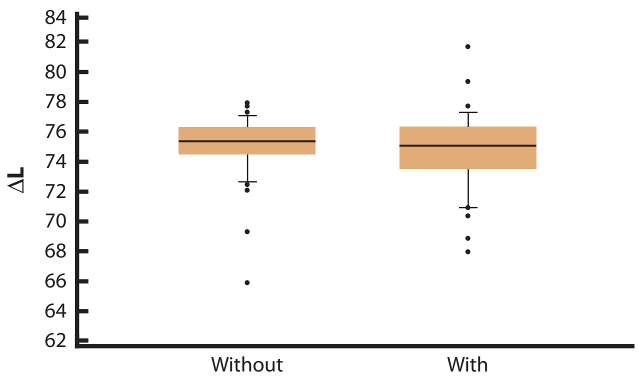

Figure 3. Delta E of lightness (ΔL*) of both measurements with and without tongue coverage.

needed, something which must be considered in upcoming study designs.

In dental practice, however, electronic devices are used to determine tooth color on a routine basis. These devices represent an additional tool to enhance the communication of color to the dental technician. Nevertheless, in clinical dental practice, subjective visual color determination is still frequently practiced[2] and requires a continuous comparison with the reference tooth. As the literature suggests, environmental parameters have a substantial influence on the visually subjective determination of color,[3,4] complicating adequate color determination.

The reason for this is that natural teeth do not exhibit color homogeneity.[18] Dental surface structure as well as the existence of a natural saliva coating affect the reflection of light and can thereby influence subjective color perception. Intra- and interindividual user differences and the dependency on physical, physiological, and pathophysiological causes all complicate international standardization efforts.[19,33-35]

The use of digital devices for determining tooth color can help minimize errors in decision. Most available instrumental color determination systems are based on spectrometric measurement devices. They increase reproducibility in repeated measurements.[21,28,30] Color measurements illuminate the initial layers of the tooth (2-4 mm) with the reference light and, subsequently, the reflected light. In addition, the shadow of the light is analyzed in the spectrograph as part of the emission spectrum. The use of tooth color measurement devices minimizes external influences and diminishes user influences so that a higher reproducibility of tooth color measurements can be obtained.[19,31]

Contrary to the study by Della Bona et al,[18] who suggested that the application of the color measuring system must involve trained and instructed dental practitioners, we found that neither user nor intraoral environmental condition had any substantial influence on measurement accuracy. The present study also reveals that the coverage of the tongue plays only a subordinate role in the making of the intraoral shade of the measured tooth.

CONCLUSIONS

Based on the findings of this clinical study, the following conclusions were drawn:

1. The coverage of the oral surface of maxillary incisors by the tongue does not influence color determination accuracy with Vita Easyshade Advance 4.0 (VITA Zahnfabrik).
2. To detect significant differences between both of the measurements, the number of participants should be increased in further studies.
3. Electronic-based devices for tooth color determination eliminate the influences of the surroundings and achieve an optimal color communication with the dental technician, enhancing technical services.
4. From a clinical point of view, intraoral images may provide an additional source of information on enamel cracks or discoloration. This is another successful tool for the fabrication of highly esthetic restorations in the dental laboratory.

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