Evaluation of Visual and Spectrophotometric Shade Analyses: A Clinical Comparison of 3,758 Teeth

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This study aimed to evaluate the performance of visual and spectrophotometric tooth shade analysis. Two operators independently selected the best match of 3,758 anterior teeth of 106 patients at 3 different dates, using the Chromascop-Complete shade guide. Additionally, tooth color was analyzed 3 consecutive times using a reflectance spectrophotometer. Spectrophotometry showed high agreement values (89.6%); both examiners agreed in 49.7% of the measurements. Visual assessment resulted in significantly darker ratings than spectrophotometry ($P < .0005$). However, a positive association was observed for both procedures ($P = .548$). Spectrophotometric shade determination seems to be significantly more reproducible than the visual procedure. *Int J Prosthodont 2007;20:414–416.*

Because of the complexity of factors interfering with individual color perception, visual shade determination is considered to be subjective. To overcome these factors, spectrophotometric shade assessment has been recommended for improved visualization and communication in dentistry.[1] The aim of this study was to *(1)* evaluate the comparability of visual and spectrophotometric assessments (null hypothesis: the spectrophotometer is superior to visual shade assessment), and *(2)* scrutinize the conformity of visual and spectrophotometric analyses (null hypothesis: the 2 methods do not correlate).

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Materials and Methods

Data obtained from 2 single-blind randomized clinical trials (106 patients) investigating the efficacy of low-concentration bleaching agents were analyzed.[2,3] Both studies had identical protocols and were approved by the Ethical Committee of the Charité-Universitätsmedizin Berlin, Germany (nos. 32/2003 and 176/2003).

Two experienced female examiners (E1 and E2, with no known color deficiencies) independently selected—in the same room at daylight—the best match of the polished middle third of the labial surfaces of the patients' maxillary and mandibular anterior teeth (free of caries and restorations, n = 3,758), using the Chromascop-Complete shade guide (Ivoclar Vivadent). Visual assessment took place in half-hour intervals prior to bleaching and after 2 and 24 weeks. For the computer-assisted assessment, SpectroShade 2.20 (MHT) was used under identical conditions. In all cases the system was calibrated prior to each assessment, with no ambient light. Each tooth was analyzed 3 consecutive times (SP1, SP2, SP3). Reflectance spectra of each measurement (parameter E for value, chroma, and hue) were compared to the lowest ΔE in the comprehensive library of the Chromascop-Complete shade guide, and the closest match was recorded.

For statistical analysis (SPSS 12.01, SPSS), the lightness values (L) of the 24 tabs of the Chromascop-Complete shade guide were measured using SpectroShade, thus leading to a numeric ranking from the lightest (1) to the darkest (24) L value. Differences among the tooth shades were analyzed using non-

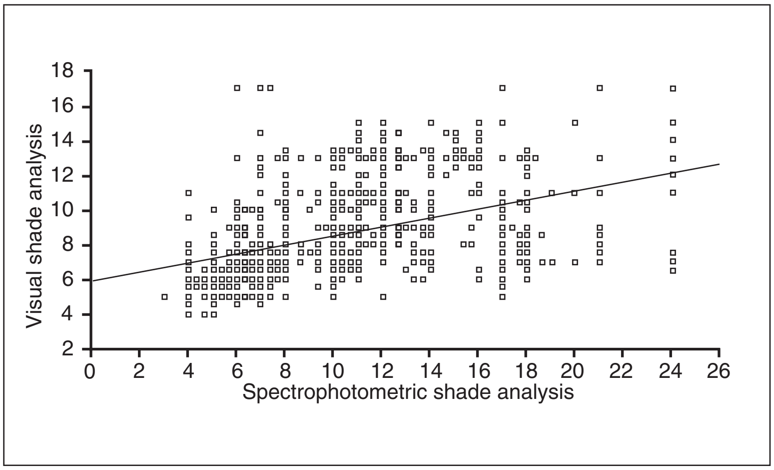

Fig 1 Scatterplot with linear fit line demonstrating the positive correlation between visual and spectrophotometric shade assessments (n = 3,758) (Spearman rank correlation: P = .548, P < .0005; α = .01 for 2-sided correlation). Identical values of the scaled data were computed but are only displayed once (even if multiple values exist). The x- and y-axes represent the numerically ranked tabs from lightest (1) to darkest (24) color.

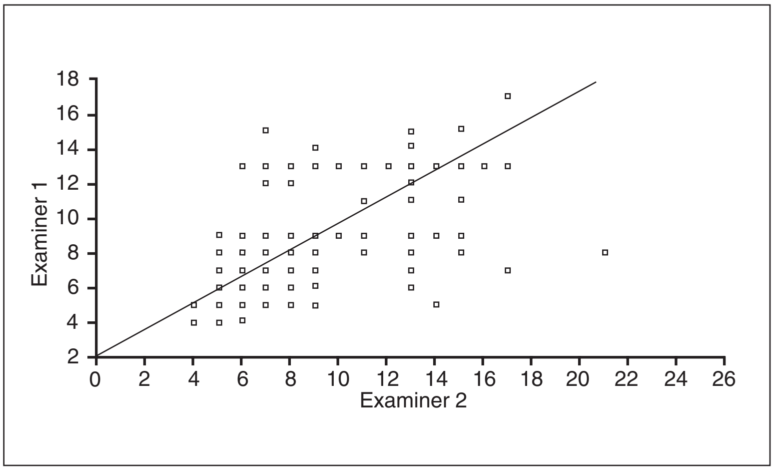

Fig 2 Scatterplot with linear fit line demonstrating the positive correlation between the 2 examiners' assessments (n = 3,758) (Spearman rank correlation: P = .775, P < .0005; α = .01 for 2-sided correlation). Identical values of the scaled data were computed but are only displayed once (even if multiple values exist). The x- and y-axes represent the numerically ranked tabs from lightest (1) to darkest (24) color.

parametric tests (Wilcoxon test, paired samples). Possible correlations between the examiners and between the 2 methods of assessment were computed (Spearman rank correlation). The level of significance was set at $\alpha = .0125$ (Bonferroni correction).

Results

The results showed that 47.9% of the visual shade selections were identical (E1 = E2). Spectrophotometric shade assessments were identical in 89.6% of the cases (SP1 = SP2 = SP3). A perfect agreement between visual and spectrophotometric shade determinations was found in only 18.2% of the cases. Visual shade determination assessed tooth colors as significantly darker than spectrophotometry ($P < .0005$). Both methods showed a weak positive correlation ($P = .548$; $P < .0005$) (Fig 1). Interevaluator correlation revealed a positive association ($P = .775$; $P < .0005$) (Fig 2).

Discussion

With an interevaluator agreement of barely half the cases, the present study demonstrated the subjectivity of visual shade assessment (even if shade assessment was positively correlated). In contrast, the spectrophotometer selected an identical shade match with respect to all 3 color determinations in most cases, and revealed a good intra-agreement. These results are in accordance with another study.[4] As a result of the mathematical quantification of color, reflectance spectrophotometers enable standardization of shade analysis and allow for precise measurements in CIE L*a*b* units.[4] Thus, the first null hypothesis was accepted.

Moreover, visual shade assessment revealed significantly darker tooth colors compared to the spectrophotometric evaluation. Again, this is in agreement with a previous study indicating that visual shade determination tends to select darker colors than the reflectance spectrophotometer.[4] Despite the low shade match agreement between visual and computer-aided shade determinations, both methods showed a weak positive association (thus rejecting the second null hypothesis). Estimation errors caused by misleading color perceptions are obvious, and subjective tooth shade determination seems to be biased.

Conclusion

Spectrophotometric shade analysis seems to be more reproducible than visual shade determination. Both procedures correlate, but visual assessment results in variational (primarily darker) recordings.

References

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Literature Abstract

Tactile sensibility of single-tooth implants and natural teeth

The purpose of this randomized split-mouth clinical trial was to determine the active tactile sensibility between singe-tooth implants and opposing natural teeth and to compare it with the tactile sensibility of pairs of natural teeth on the contralateral side in the same mouth (intraindividual comparison). The null hypothesis was that the active tactile sensibilities of the implant side and control side are equivalent. Sixty-two subjects (n = 36 from Bonn, Germany; n = 26 from Bern, Switzerland) with single-tooth implants (22 anterior and 40 posterior) were asked to bite down on narrow copper foil strips varying in thickness (5 to 200 µm) and to decide whether or not they were able to identify a foreign body between their teeth. In the anterior region (incisors and canines), the tactile tests were performed in the incisal-edge-to-incisal-edge position; in the posterior region (premolars and molars), they were performed in maximum intercuspation of the mandible. The foreign bodies placed between the teeth consisted of copper foils that were about 3 mm wide with varying thickness. Active tactile sensibility was defined as the 50% threshold of correct answers estimated by means of the Weibull distribution. The results obtained for the interocclusal perception sensibility differed between subjects far more than they differed between natural teeth and implants in the same individual (implant/natural tooth: 16.7 ± 11.3 µm [0.6 to 53.1 µm]; natural tooth/natural tooth: 14.3 ± 10.6 µm [0.5 to 68.2 µm]). The intraindividual differences only amounted to a mean value of 2.4 ± 9.4 µm (–15.1 to 27.5 µm). The result of the statistical calculations showed that the active tactile sensibility of single-tooth implants, both in the anterior and posterior regions, in combination with a natural opposing tooth is similar to that of pairs of opposing natural teeth (double *t* test, equivalence margin: ±8 µm, $P < .001$, power > 80%). Hence, the implants could be integrated in the stomatognathic control circuit.

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