Short Communication

Interexaminer Reliability in the Clinical Measurement of L*C*h* Values Using a Laminar Spectrophotometer

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This in vivo study investigated interexaminer reliability in the clinical measurement of L*C*h* values using a spectrophotometer (Shadepilot, DeguDent), which provides laminar measurement. Thirty incisors were measured by 3 trained clinicians. Intraclass correlation coefficient was used to assess reliability. Additionally, the range of differences between the measurements by all examiners for each subject was calculated to assess the clinical impact of the differences. Agreement was acceptable to excellent for all measurements. Additionally, the reliability of the measurement of L* and C* was excellent (all measurements < 5). Laminar spectrophotometric measurement seems to be superior to punctiform measurement. *Int J Prosthodont 2008;21:422–424.*

In recent years, the development of spectrophotometers for the evaluation of tooth shades has greatly progressed. Thus, it may be possible to overcome the problems of human observation of tooth shades (eg, subjectiveness). Further, communication with dental technicians could be based on objective data. However, computerized data collection is subject to error[1] because agreement between different examiners can vary.[2]

Most spectrophotometers use punctiform measurements, resulting in either the need to measure several areas or inaccuracies with respect to the description of the shade. Thus, a reliable spectrophotometer measuring the whole tooth in a single measurement with good interexaminer agreement would improve the computerized measurement and aid in communication between clinicians and technicians.

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The aim of this clinical study was to assess the interexaminer reliability of a new spectrophotometer (Shadepilot, DeguDent), which provides laminar measurements instead of punctiform. The null hypothesis was that interexaminer agreement is excellent when using the latest spectrophotometers.

Materials and Methods

Spectrophotometer

The Shadepilot uses wavelengths ranging from 410 to 680 nm with telecentric and monochromatic lighting (2 × 45-degree angle). Illumination is provided by 8 semi-monochromatic light-emitting diodes (LEDs) covering the whole visible spectrum of light, with "tails" reaching ultraviolet and infrared. Each LED is activated consecutively, and the reflectance is detected via the charge-coupled device array. Using the emission spectra from the illumination source, it is possible to recalculate and calibrate the remission from the tooth. Forty-five-degree illumination is important to obtain diffuse illumination as seen by the human eye (avoiding predominately back-scattered light with a significant wave-length dependence). Calibration is a prerequisite to avoid thermal drift of optic and electronic parts and is accomplished using ceramic tiles with white and green surface colors. The measurement area was approximately 18 × 14 mm, and the digital resolution was 640 × 480 pixels. The instrument offers several modes for measurement. In this study, the triple-zone measurement was chosen to analyze the tooth shade.

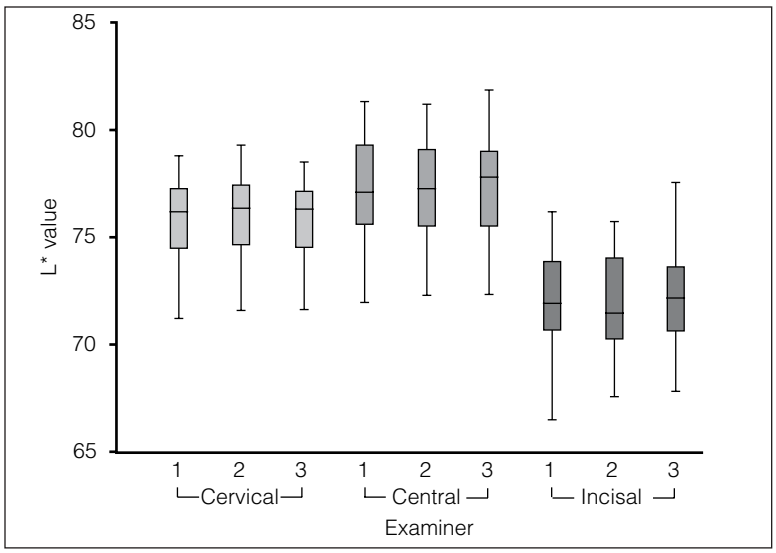

Fig 1 L* values for all 3 examiners.

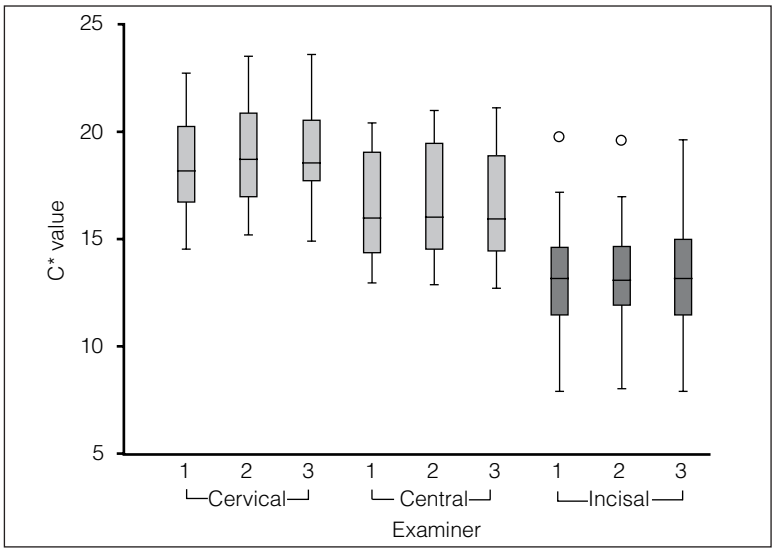

Fig 2 C* values for all 3 examiners.

Examiners

Three clinicians (2 men and 1 woman) served as examiners (1, 2, and 3). All examiners received a short introduction in the usage of the Shadepilot, and proper handling was demonstrated.

Subjects

The study was approved by the local review committee for human research, and all subjects signed an informed consent form. Thirty volunteer subjects were recruited from a population of dental students (15 female and 15 male; mean age: 21.4 years).

Measurement

The measurement was performed according to the manufacturer`s guidelines. A disinfected mouthpiece was placed, and the appliance was calibrated before the measurement. The measurement was accepted if the positioning, which is supervised by the angle control system of the Shadepilot, was correct (deviation $<$ 0.5 degrees). Next, the L*C*h* (value, chroma, hue) of each third of the teeth (cervical, central, incisal) was measured. L*C*h* values represent cylindric coordinates in the color space, whereas L*a*b* values represent Cartesian coordinates. The L*C*h values were used to provide comparability with recent studies.[2] However, a* and b* can be calculated with 2 simple formulas: $C = \sqrt{(a^{*2} + b^{*2})}$ and $h = \arctan(b^* / a^*)$.

Statistical Analysis

Interexaminer reliability was calculated using intraclass correlation coefficients (ICCs). An ICC $>$ 0.75 was considered to be excellent, and $0.4 < ICC \leq 0.75$[3] was considered as acceptable. The differences

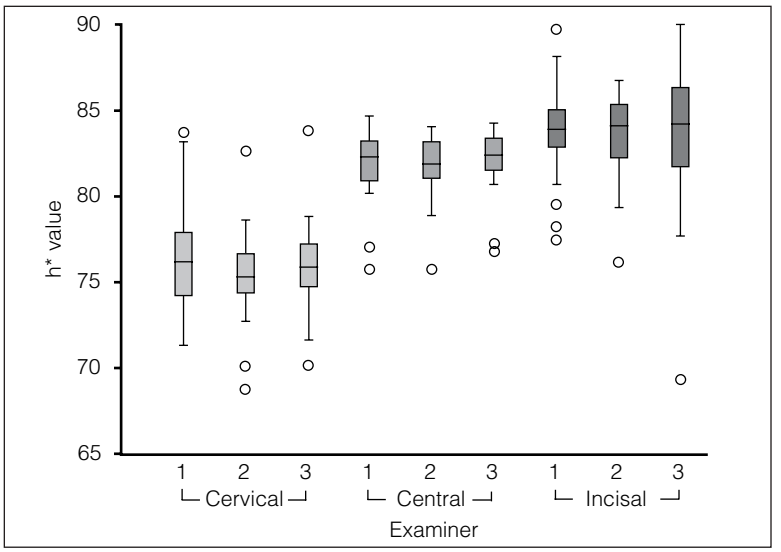

Fig 3 h* values for all 3 examiners.

Table 1 Intraclass Correlation Coefficients (99% Confidence Intervals) for All Measurements

	L*	C*	h*
Cervical	0.844 (0.694–0.932)	0.951 (0.895–0.980)	0.722 (0.497–0.873)
Central	0.951 (0.895–0.980)	0.953 (0.901–0.981)	0.850 (0.703–0.935)
Incisal	0.882 (0.761–0.950)	0.954 (0.902–0.981)	0.663 (0.413–0.841)

between the L*, C*, and h* measurements by all examiners for each subject were calculated. To clarify the clinical impact of these differences, the percentage of L*, C*, and h* ranges above $\Delta L^* = 5$ degrees, $\Delta C^* = 5$ degrees, and $\Delta h^* = 2$ degrees were reported.[2]

Results

The results for the L*C*h* measurements are shown in Figs 1 to 3. The ICC ranged from 0.663 (H*, incisal) to 0.953 (C*, central). Detailed results are shown in Table 1, including the 99% confidence intervals. The maximum ΔL^* was 3.3, the maximum ΔC^* was 4.3, and the maximum Δ^*h was 7.0.

Discussion

Both L* and C* had an excellent ICC. The ICC values for h* measurements were lower, but still reached an acceptable level. This result is comparable to the results of another study[4] reporting ICC > 0.9 for shade and value and $0.64 < \text{ICC} < 0.74$ for hue. However, this study used punctiform measurement.

Δh^* was > 2 in 18.52% of all possible comparisons (examiner 1 versus 2, 1 versus 3, and 2 versus 3 for 30 subjects = 270 combinations).

Since ΔE is influenced by L*, C*, and h*,[5] it might vary slightly because of the variation of h*. However, since the differences in the measurement of L* and C* are $<$ 5, the variability of ΔE is limited. Additionally, the clinical impact of $\Delta h^* > 2$ depends on the position of L* and C* in the color space. Thus, in bright teeth with low chroma, the clinical impact of $\Delta h^* > 2$ is low.

Conclusions

Laminar measurement of the tooth shade results in acceptable/excellent interexaminer reliability. The reliability of the measurements of L* and C* seems to be superior to that of punctiform measurements. Further, laminar measurement allows for simultaneous measurement of different areas of the tooth.

References

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