Evaluating Color Consistency of Shade Tabs with Digital Image Analysis

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ABSTRACT

Objective: The standard numerical ordering of dental shade tabs, which is used to measure color change in clinical trials, may be affected by guide-to-guide variations. New research was conducted to assess the color consistency of shade tabs using standardized digital imaging, and in addition, to establish 3-dimensional color measurement repeatability of that method under common conditions. **Methods:** All 16 shade tabs from 3 different shade guides (VITAPAN® classical) were randomized (1-48), placed individually in a stent, and imaged using a high speed camera under controlled lighting conditions. The process was repeated three times (each tab was removed and replaced to measure repeatability), and then L*a*b* color was derived using standard methods. Analysis of variance was used to assess imaging measurement repeatability, and to estimate between-guide consistency for common tabs. Cluster analysis of the mean L*a*b* scores was used to determine the distinctiveness of individual shade tabs. **Results:** Repeated measures variance for individual tabs were 0.005 for L* (lightness), 0.002 for a* (redness), and 0.002 for b* (yellowness). Inter-guide consistency varied by tab ($p < 0.001$). The D2 & D3 tabs were the least consistent, differing by more than 1-unit in L* & b*. While there were 11 distinct clusters matching actual tabs, there were 5 indistinct clusters involving tabs A2, B2, C2, D2, D3. The cluster analysis suggests that between-guide variations could contribute 2-shade differences in measurement. **Conclusion: This research establishes the ex vivo measurement repeatability of digital image analysis to assess tooth color, and demonstrates the significant between-guide variability in tab color, that may impact accuracy of change measurement using this subjective method.**

OBJECTIVE

Dental shade guides are often used in clinical trials to measure tooth color change. Guide-to-guide variation can negatively impact the relevance of standard numerical ordering commonly used in these trials. This research was conducted to assess the color consistency of shade tabs using standardized digital imaging, and in addition, to establish 3-dimensional color measurement repeatability of that method under common conditions.

MATERIALS AND METHODS

A total of 48 shade tabs from 3 different shade guides (VITAPAN® classical) were individually placed in a stent and imaged using a high speed camera under controlled lighting conditions. The order of imaging was randomized. This process was repeated two additional times with each tab being replaced into the stent. L*a*b* color was then derived for all images using standard methods.

L*a*b* data were analyzed using an analysis of variance model including terms for guide, replication within guide, vita shade and guide by vita shade interaction. The model residual variance was used to estimate repeatability. This model was fit using SAS® separately for L*, a* and b*. L*a*b* means for each of the 48 shade tabs were subjected to a k-means cluster analysis. This analysis was performed using SPSS® with default options and specification of 16 clusters.

RESULTS

Repeated measures variances for individual tabs were 0.005 for L* (lightness), 0.002 for a* (redness), and 0.002 for b* (yellowness). Inter-guide consistency varied by tab (p < 0.001) for all measures. The D2 & D3 tabs were the least consistent, differing by more than 1-unit in L* & b*.

Figure 1 displays individual b* readings for all 3 repeated measurements for all 16 tabs from each of the 3 guides. High consistency of repeated measurements can be seen along with clear differences between guides for the same labeled tabs (e.g. B1). Results for L* and a* are similar.

Only 11 of the 16 clusters identified in the cluster analysis matched the tabs. Those not correctly clustered include A2, B2, C2, D2 and D3. Figure 2 displays the average L* and b* readings for each of the individual tabs. The lack of distinction between the five tabs in L* and b* is clear. This cluster analysis suggests that between-guide variations could contribute 2-shade differences in measurement.

FIGURES AND TABLES

Figure 1: Replicate CIE b Readings by Guide and Vita Tab*
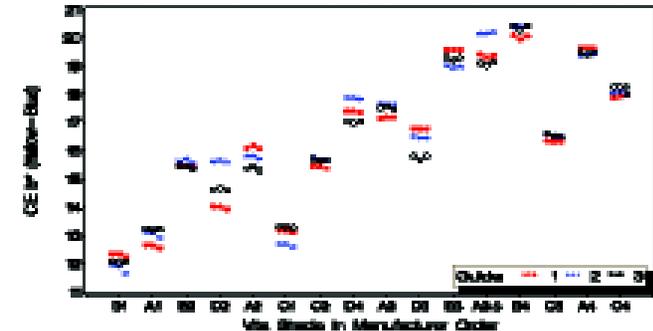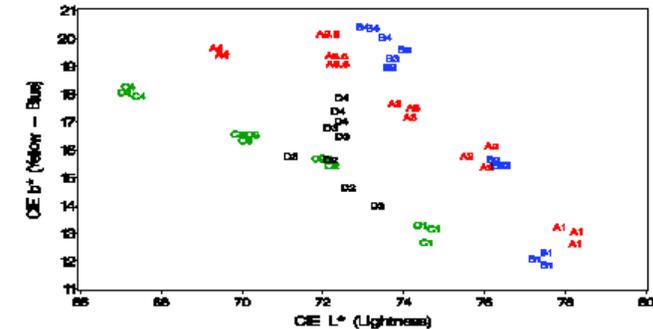

Figure 2: Average L and b* by Guide and Vita Tab*

CONCLUSION

This research establishes the ex vivo measurement repeatability of digital image analysis to assess tooth color, and demonstrates the significant between-guide variability in tab color, that may impact accuracy of change measurement using this subjective method.

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