Shade Analysis by Digitally Flipping Shade Tabs

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Abstract
A technique for clinical shade analysis is presented. The technique involves first eliminating shade tabs with dissimilar shades, and then taking digital images of the target tooth with a shade tab aligned edge-to-edge. The image of the shade tab is then digitally duplicated, cropped, and flipped. The cropped and flipped shade tab is aligned adjacent to the target tooth to visualize the color gradient.

Introduction
Accurate shade matching and communication with the dental laboratory is important in providing patients with esthetically pleasing restorations. Currently, color assessment methods include: visual assessment with shade guides, spectrophotometry, colorimetry, and computer analysis of digital images [1]. There has been a considerable amount of research aimed at making visual assessment more accurate, such as determining value prior to chroma and hue, and varying the arrangement of shade tabs [2-4]. However, studies have found lower levels of accuracy for visual shade matching when compared with instrument-based methods [5-8]. Even among instrument-based methods, there is considerable variation in accuracy between different systems [9-12]. Moreover, it is difficult to assess the color gradient of the tooth with popular spectrophotometers, because of the size of the probe diameter [6].

Recently, computer analysis of digital images has been studied as a method for color assessment [13-16]. One method is to take a digital photograph with all 26 shade tabs in the same image, and digitally assessing color using computer software [13]. Another method is to prepare a "digital shade guide", by taking individual images of shade tabs, and cropping the digital shade tab images [14]. These images are then overlayed onto the digital image of the target tooth for computer analysis [14]. However, these techniques may be limited in accuracy due to the inconsistency in lighting of commercially available flashes [16].

Another advancement that has gained popularity is the utilization of Feld spathic porcelains with multiple shades [17]. With the myriad of porcelain shades to choose from, it has become increasingly important to perform color mapping of teeth [17]. Simple methods of color mapping include dividing the tooth into gingival, middle, and incisal thirds [18,19]. Advanced methods of color mapping detail the location of specific porcelains to mimic intrinsic and extrinsic characterizations of teeth [20]. These detailed color maps require considerable experience, and are not easily created with most instrumental methods [6,14]. This manuscript describes a technique for clinical shade matching and analysis, using digital photography and computer software.

Technique

- Wet the teeth and the shade tabs, retract lips using lip retractors.
- Using a process of elimination, eliminate shade tabs that are clearly dissimilar to the target tooth. Three to five shade tabs should remain.
- Place one shade tab close to the tooth to be matched, so that the incisal edges are directed toward each other. There should be approximately 1 mm of space between the incisal edges of the tooth and the shade tab.
- Take a digital image of the tooth along with the shade tab, making sure that the long axis of the tooth and the shade tab are directed perpendicular to the horizontal plane of the image taken. The shade number should be clearly visible (Figure 1).
  - After taking the image, check to make sure it is not overexposed or underexposed. Compensate for overexposure or underexposure by either adjusting the flash lighting, shutter speed, aperture size (F-Stop), and/or ISO.
  - The reflection from the flash should be near the middle to cervical third of the target tooth and the shade tab.
  - Repeat for all remaining shade tabs
- Download all of the images to a personal computer
- Using image editing or presentation software (Photoshop CS5, Adobe), duplicate one side of the shade tab on the image.
- Rotate the duplicate image, and place over the target tooth. Resize the cropped duplicate image to align the incisal edges and gingival margins (Figure 2).
  - Repeat for all remaining shade tabs
- Print out the images in a high quality color printer and send to source are credited.

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which makes inconsistencies from simultaneous contrast more likely.

whereas the shade tab is surrounded by the darkness of the oral cavity, as lateral inhibition of neurons and the principle of belongingness be darker (Figure 4). This phenomenon is explained by theories such when one color is surrounded by a darker color, it appears to be lighter, and when it is surrounded by a lighter color, it appears to be darker (Figure 4). This phenomenon is explained by theories such as lateral inhibition of neurons and the principle of belongingness. The target tooth is surrounded by the lightness of adjacent teeth, whereas the shade tab is surrounded by the darkness of the oral cavity, which makes inconsistencies from simultaneous contrast more likely.

Discussion

The principle of simultaneous contrast dictates that different colors placed side by side affects the perception of the intensity of the color [21]. When one color is surrounded by a darker color, it appears to be lighter, and when it is surrounded by a lighter color, it appears to be darker (Figure 4). This phenomenon is explained by theories such as lateral inhibition of neurons and the principle of belongingness [22]. The target tooth is surrounded by the lightness of adjacent teeth, whereas the shade tab is surrounded by the darkness of the oral cavity, which makes inconsistencies from simultaneous contrast more likely.

In addition, because the distance between the cervical portion of the tooth and the shade tab is greater than that of the incisal edges, the cervical shade may be the most difficult to match. The present technique eliminates this difference by placing the shade tab directly adjacent to the target tooth.

Schropp [13] described a technique in which all 26 shade tabs and the target tooth are in the same image. In the present technique, only one shade tab is used at a time, which allows the shade tab and the target tooth to be in the same orientation and distance relative to the camera flashes. This may prevent differences in amount of light directed toward the target tooth and shade tab. The edge-to-edge orientation also prevents shadows from falling on the target tooth [17].

The major disadvantage of this technique stems from possible inaccuracies in variations in light output from camera flashes [16]. These variations include variations in light intensity during separate flash firings, and inconsistencies in the spectrum of light [16]. Jarad et al., [14] advocated a technique which combines previously taken images of shade tabs with an image of the target tooth. A perfect match rate of 61% was found using that technique [14]. The present technique may prevent such inaccuracies by keeping the image of the shade tab and the target tooth in the same image. However, inconsistencies in light intensity may still prevent finding the closest matching color. These inaccuracies may be minimized by checking the batteries of the camera flash; adjusting the white balance, aperture, shutter, and ISO settings of the camera; using an LED light source; and/or using a dual polarized system [16].

Summary

A technique for shade matching and analysis was described. Non-matching shade tabs are first eliminated. A digital image of the target tooth and one of the remaining tabs is taken, with the shade tab positioned edge to edge toward the target tooth. Multiple digital images are taken. The shade tabs are digitally duplicated, cropped, flipped, and positioned adjacent to the target tooth to facilitate visualization of color, texture, and characterization by the clinician and dental laboratory technician.

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