Improving Photographic Strategies in Shade Communication

James F. Fondriest, D.D.S.

Dr. James Fondriest has a private practice with an emphasis on esthetic, reconstructive, and implant dentistry, in Lake Forest, Illinois. Dr. Fondriest is a Pankey Scholar and a visiting faculty member at the L. D. Pankey Institute in Key Biscayne, Florida. Some of his professional memberships include the Academy of Osseointegration, the American Academy of Fixed Prosthodontics, the American Academy of Dental Practice Administration, the American College of Dentists, and the International College of Dentists.

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ABSTRACT

The ability to communicate the appearance of a tooth to the laboratory can be significantly improved with the use of photography. A picture supposedly is "worth a thousand words" and, indeed, richly characterized teeth would never be able to be well-matched without some sort of visual communication process. Strategically composing a set series of shots can magnify the value of digital or 35-mm slides. This article offers an introduction to this series of shots and a brief description of the science behind these photographic strategies.

INTRODUCTION

Well-exposed clinical photographs can document numerous details that normally might not be noticed when looking at the patient. The effective use of photography can significantly improve the accurate communication of the optical characteristics of teeth. There are three types of photographs that can effectively communicate the major parameters of a good match, which are, in order of importance: shape, surface morphology, value, translucency, chroma, and hue. Photographic documentation of these parameters can be enhanced by manipulating the background, the exposure angle of camera to the teeth, and the camera F-stop.

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The best photographic route is with color-accurate 35-mm slides or digital images, both taken with a single-lens reflex-type camera with a 90-115 mm macro lens. Arguments can be made for using either a dual-point flash or a ring flash (the author prefers a dual-point flash). The flash should be color-neutral with a color temperature of 5500 K and a color-rendering index of greater than 92.[14] If you are using slides, use a color-corrected professional quality film (e.g., Kodak™ E100-S, EPN-100, or EPP [Kodak; Rochester, NY) and have them developed by a good photo lab. Other required items are cheek retractors, black backgrounds, gray backgrounds[5] (preferably 18% reflective gray cards), and shade tabs. Shade tabs from any vendor are helpful if

Figure 1: For shape and surface morphology:

- ***clean and dry teeth***
- ***take shots perpendicular to surface***
- ***use a black background.***

Figure 2: For translucency:

- ***bracket F-stops and underexpose shots***
- ***use a black background***
- ***take shots from 60° to surface (from above)***
- ***vector shots.***

your laboratory uses that guide, or you can share your tab with the laboratory if they don't have their own while the case is completed. The Vita™ Classic shade guide (Vident; Brea, CA) is used by approximately 90% of practitioners. Unfortunately, this guide represents a minority of the natural and unnaturally brightened teeth to be matched (target teeth). It is hoped that the not-too-distant future will bring a universal full-spectrum guide that the dental material manufacturing industry will adopt.

SLIDE 1: SHAPE AND SURFACE MORPHOLOGY

To document shape and the surface morphologies texture and luster (Fig 1), the following steps should be performed:

1. retract the lips to expose the target teeth (proximal and contralateral teeth) and to allow a background to be placed
2. place a black background
3. dry the teeth
4. position the lens and flash perpendicular to the surface of the tooth being evaluated.

The black background is helpful because it increases *contrast* (the difference in brightness or color between an object form and its background[6]) between the teeth and the backdrop. Contrast is helpful when visualizing the shape or silhouette of the tooth. When a tooth's surface is wet, the water flows over the surface, visually flattening it. This camouflages the textures and decreases the effects of low luster.

It is difficult to distinguish whether a tooth has low luster, is dehydrated, or has been bleached; only a patient history will help.

The textures of teeth can be divided into three subcategories: vertical, horizontal, and malformations.[7] Vertical textures in maxillary centrals tend to be manifestations of the three developmental lobes. The horizontal textures are initially created by the laying down of enamel layer upon layer. The end of each layer leaves a line on the enamel surface, called the *striae of retzius*.[8] These striae run roughly parallel to each other and are called *perichymata*. With time, the surface of the tooth wears and the striae eventually disappear. Different sections of the tooth calcify with different levels of mineralization and hardness. In time, these dissimilarly hardened areas wear unevenly, forming larger and wider-spaced horizontal undulations. The malformation group of textures is a catch-all for stippling, cracks, craze lines, chips, and blebs.

When the lens and flash are positioned directly perpendicular to the surface of the tooth, the light can reflect like a mirror back to the camera. Surfaces that are not perpendicular will reflect the light away from the camera and highlight the texture.

The surface variations, called *luster*, are an order of magnitude (or more) smaller in size than texture. If you wet sand or acid-etch clear plate glass, the effect is to lower the luster of the surface; this resultant surface is less transparent than the untreated glass surface. When light hits the surface of the lower-luster glass, some of the light is bent at the surface. When the light is bent, the surface becomes brighter (this is why etched glass is frosty white in appearance). When water (or saliva) is applied, the glass becomes easier to see through but certainly is not transparent. A low-luster tooth will have a brighter frosty appearance to the surface, similar to the look caused by modest bleaching or dehydration. It is difficult to distinguish whether a tooth has low luster, is dehydrated, or has been bleached; only a patient history will help. A high-luster sharpens the mirror-like reflections off the tooth's surface and it also increases the ability to see under the tooth's surface.[9] A low luster makes the surface more opaque, brighter.

SLIDE 2: TRANSLUCENCY

To document the areas of translucency within teeth (Fig 2), the following steps should be taken:

1. retract the lips to expose the target tooth (proximal and contralateral tooth/teeth) and to allow a background to be placed
2. use a black background
3. position the flash and lens 60° to the surface (from above)
4. vector the shots
5. sequentially close down the F-stop (lens aperture) toward underexposure.

The translucency (the gradient between transparent and opaque) of a tooth is not far behind value in importance to a quality match.. The measurement of opacity is more important than chroma and hue in importance to a match. Most of a tooth's translucency occurs in the enamel and is highlighted by the characteristic of *opalescence* (the effect of scattering the blue light and trans-illuminating the reds and yellows).[10,11] The enamel rods act like tiny prisms and break the incident light down into its component wavelengths. The reds and yellows bend only slightly, while the blues bend the most. The reds-yellows often travel completely through the enamel, whereas the blues scatter within the body of the enamel (this is why enamel tends to look blue). There is no material within the enamel body that is blue—it is purely an optical effect. The better laboratories try to stack porcelains in layers that have the same thicknesses and optical properties as the layers of the tooth. They don't put blue stains in the restoration; rather, they count on the fact that the porcelains have the same optical properties as the corresponding layers of the tooth.

The blue opalescence is the clue as to where the translucent enamel is in the tooth. The opalescence is not as evident in areas that are backed by dentin. The reds and yellows that penetrate the enamel, which would normally escape out the lingual of the unsupported enamel, hit the dentin and reflect back into the enamel adding itself again with the blues recomposing to near white light. This effectively cancels the opalescent effect. If we create the circumstances to maximize our ability to see this opalescence in photos, we will improve our ability to describe enamel thicknesses to the lab.

A background is useful because it stops the reflections, which the flash accentuates, off the back of the mouth. The red reflections coming off of the palatal tissues travel back through the enamel and remix with the blues, also nullifying the opalescent effect.[12] Using a black background will increase the contrast between the blue opalescent enamel and the perimeter of red-yellow dentin below.

Varying the film exposure can be accomplished in several ways and is called *bracketing*. One type of bracketing is the adjustment of the aperture or F-stop while taking multiple exposures. When the aperture is closed down, less light will make it to the film or digital sensors. Bracketing the F-stops is beneficial in documentation photography because you often see different things at different settings. Closing down the F-stop will decrease the influence of surface reflections but will not decrease your ability to see the opalescence. It also increases the depth of field. Closing down the F-stop will increase your ability to see the layers within the tooth, which is helpful for determining translucency, hue, and chroma.[13] The camera has to be set to "manual" with a constant shutter speed and flash. The through-the-lens (TTL) flash setting cannot be used. You can send all of the exposures to the laboratory, but you will begin to notice that the slightly underexposed images deliver more information.

Vectoring is taking pictures at different angles. By taking shots at different vectors, we are able to visualize interproximal volumes of translucent enamel not backed by the dentin, and without getting the red-yellow reflections of proximal teeth. Camera flash reflections are very helpful when evaluating textures. However, as these reflections come off of the tooth, they obscure our view below the surface. We want to minimize the flash reflections in our photograph when evaluating translucency. The target tooth can be wetted for translucency, hue, and chroma evaluation to limit the influence of surface morphology. By angling the lens away from perpendicular to the target tooth surface and taking the shot either from above or below (>30°), we limit reflections. Ring flashes tend to surround the exposure field and yield more reflections. More angulation may be necessary with a ring flash.

Figure 3: For chroma, hue, and value:
- ***take shots at 60° from surface (incisal edge away from camera)***
- ***make sure that shade tabs and target teeth are parallel and equidistant from camera***
- ***use an 18% reflective gray card for background***
- ***vector shots***
- ***include occlusal and incisal shots.***

SLIDE 3: CHROMA, HUE, AND VALUE

To document chroma, hue, and value, the following steps should be performed (Fig 3):

1. retract the lips to expose the target tooth (proximal and contralateral teeth) and to allow a background to be placed
2. use an 18% reflective gray card as a background
3. choose a set of tabs that will match each layer within the tooth for hue and chroma, and a set (on value scale) for the sum total brightness of the tooth (for anterior teeth, a set of three shade tabs usually will fit within the photo)
4. to compose a set, make an ideal tab selection and add two shade tabs, one chroma stop above and one below the ideal selection
5. orient tabs incisal edge to incisal edge to the target teeth
6. make sure that shade tab surfaces are parallel to the target teeth and equidistant with the target teeth from the camera
7. minimize reflections by angling lens >30° above or below perpendicular
8. take photos at several vectors
9. bracket F stops manually (do not use the TTL setting on the flash, close the lens setting incrementally).

Visual distortions dramatically affect our ability to render color.[6] The two main distortions in dental circumstances are the spreading effect and the negative after-image. Simply stated, the spreading effect occurs whenever two dissimilarly colored objects are placed next to each other. Because our eyes don't stared fixedly at an object but rather continually roam the visual field, the color of each object is mixed with the other and the objects soon (within seconds) appear more alike. If some distance is placed between the tooth and the mid-buccal part of the shade guide, a better assessment can be made. Some advocate grinding off the incisal edge of the Vita™ Classic shade tabs, but they do help to provide the little visual separation that lessens the spreading effect.[7] Orient the shade tabs so that the incisal edge of the tab co-approximates the incisal edge of the tooth.

When illuminated with white light, opaque objects will absorb some wavelengths and reflect others. The object takes on the color of the wavelengths that are reflected. When we mix opaque porcelain pigments, paints, dyes, or lacquers, the mixture of two colors will always be darker than the original two colors. Opaque color-mixing follows the subtractive laws of color: each pigment absorbs a certain part of the spectrum and when mixed with another pigment, the combination absorbs more of the spectrum. When all colors are mixed together, they turn an ugly gray-brown. The photographic and color industries use this gray-brown as a standard achromatic (no single color dominant) background. Looking at this background is very restful to the cones and improves our ability to render hue.[5]

Contrast is caused by a difference between the brightness or color of an object and its immediate background. Object forms with high contrast are easier to discern than objects with low contrast. Although some contrast is helpful to our visual system, excessive contrast causes glare, which reduces our ability to perceive visual information.[2,6] Preston recommended that the illumination of the teeth should not be significantly brighter than the ambient environment.[14] With dental photography, the use of a black background increases impact, but it will cause glare. This is counterproductive when matching hue and chroma, and it will mask shade mismatches.

Negative after-images are caused by fatigue of the cones within our eyes. Within milliseconds of observing any colored object, we begin to preferentially perceive the complementary hue. Limiting the reds and other colors in the slide background minimizes these negative after-images. The most appropriate background for hue-rendering of any type is neutral gray. When framing your picture, you can minimize the influence of red by using a standardized gray-brown background and cropping as much of the gingiva as possible without cropping any part of the target tooth.

The positioning of the shade tabs affects the quality of information they portray. If they are not equidistant with the target teeth from the camera, they will appear brighter or darker than they really are. They should also be parallel to the tooth surface being exposed. Light that reflects off surfaces perpendicular to us comes back to our eyes. If the surface illuminated is not perpendicular, more light is reflected away from our eyes. The further from perpendicular, the darker that surface becomes. If the shade tab is not parallel to the tooth surface, it will reflect light differently and the chroma and value assessments will be inaccurate. Remember to minimize the flash reflections off of the tooth and the shade tab or the photo will be valuable only for textures, not for chroma, hue, or value. Flash reflections do not take on the color of the tooth but rather return with the same wavelength spectrum released from the flash.

You can send all of the exposures to the laboratory, but you will begin to notice that the slightly underexposed images deliver more information.

The rods of the enamel are roughly perpendicular to the surface of the tooth. When light hits the surface, it follows down the enamel rods to the dentin. We can see the dentin best while observing from directly above. Enamel is *anisotrophic*, meaning that light does not travel as easily diagonally across the rods as it does going parallel down the rods.[15] Because the translucency of enamel is directionally dependent, vectoring is beneficial when trying to capture maverick colorations buried within the deeper layers of the target teeth. Needless to say, photos from the incisal/occlusal views also are valuable in the photographic documentation of the target teeth. Use as many tabs as you see colors in the tooth. If you see more than one hue family in a tooth/arch, then photograph all the tabs that seem to match. Suggest ratios to the lab in the prescription.

CONCLUSION

Any photograph will be far more useful than no visual documentation. There are measurable advantages to choreographing shots with different backgrounds, exposure angles, and F-stops. The more information that we can deliver to our laboratory partners, the better our results will be.

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