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## Shade Matching for Indirect Restorations in the Esthetic Zone

### ABSTRACT

Selecting the proper shade for an indirect restoration in the esthetic zone is of paramount importance. The process can be both difficult and time consuming. This article delineates a clinical protocol for shade taking, laboratory communication, and assessment of the final restoration to make the process easier and more accurate. In addition, there will be limited discussion of color, shade guides, office environment, instrumentation, digital photography, placement, and troubleshooting.

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### INTRODUCTION

Matching a shade for one or more indirect restorations in the esthetic zone can be very difficult, time consuming, frustrating, and expensive. The dentist, laboratory technician, and patient all are involved in the process. An improper shade selection, poor laboratory communication, or an inadequate assessment of the final restoration by the dentist and patient can lead to an esthetic failure.

The appearance of a tooth is not monochromatic; but, rather, a blend of various shades, translucencies, opacities, surface textures, gloss, and characterizations (e.g., maverick colors, craze lines, perikymata, incisal halos, hypocalcification marks). Therefore, simply picking a shade tab to communicate the desired appearance of the restoration to the laboratory is inadequate. Today's clinician must accurately select the matching shade, properly communicate the tooth's appearance to the laboratory technician, and be able to assess the final restoration before placement.



Figure 1: Various preoperative views of the mismatched PFM crown on tooth #7 in context with adjacent teeth. Photographs are taken from various angles, with and without retraction.

### COLOR AND SHADE ASSESSMENT CONSIDERATIONS

The first requirement for the clinician is to have a basic knowledge of color in order to begin the process of shade selection. The Munsell Color System divides color into hue, chroma, and value. Simply stated, hue is the actual "color" (e.g., yellow, brown); chroma is the saturation or degree of hue; and value is the hue's relative lightness or darkness.

Selecting a color can be accomplished in several ways. The two most widely used methods are visual selection, or via photocolometric instrumentation. The former is fraught with more variables than is the latter. The clinician's knowledge, color perception, and ocular fatigue can all contribute to inaccurate assessments.<sup>1</sup> Shade selection with an electronic shade-taking device (e.g., Easyshade [Vita, Vident; Brea, CA]; ShadeEye [Shofu, San Marcos, CA]; ShadeVision [X-Rite, York Dental; Branford, CT]) offers a reliable alternative to visual shade matching.<sup>2,3</sup> This allows dentists and others to eliminate inaccuracies associated with visual assessment alone.

Shade guides are needed to communicate to the laboratory the se-

lected hue or color. Also, the electronic shade-taking devices often are keyed to shade guides. A number of shade guides are available but I believe that the one that best replicates the teeth's hues, value, and chroma is the Vita 3-D Master Shade Guide.<sup>4,5</sup> This guide is composed of the yellow-red color space that naturally occurs in teeth. The tabs are arranged from high value to low value, and within each value group are yellow and red hues and various chromas.

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The office environment where the shade selection process and evaluation of the restoration take place also can play an important role in color perception. Lighting, office décor, and bold colors near the oral cavity can influence shade selection.

Office lighting should, ideally, be a combination of natural daylight and color-corrected fluorescent lighting. Natural light should be indirect and the fluorescent bulbs optimally

should be 5500 Kelvin color temperature, 1600-2100 Lux intensity, and have a Color Rendering Index of 90 or greater.<sup>6,7</sup> Using a variety of light sources can lessen the problem of metamerism, which is the change in appearance of an object under various light sources. Additionally, diffusers should not be used on the light source as they change the bulbs' properties. The treatment room environment (floors, ceilings, and cabinetry) should have a neutral light gray background.<sup>8</sup> A patient's lipstick, clothing, and clinical drape also can adversely affect the clinician's color perception.

### LABORATORY COMMUNICATION

One of the main problems that technicians have with dentist-laboratory communications is that of shade selection.<sup>9</sup> Along with proper shade selection, the dentist must communicate the various tooth characteristics such as translucency and surface texture. This is best accomplished by the use of digital photography.<sup>10</sup>

Photographs should be taken of the teeth preoperatively and with the selected shade tabs; and of the preparation with a matching shade



*Figure 2: Spectrophotometer taking the shade of the contralateral tooth.*



*Figure 3: The selected shade tab is photographed in line with the long axis of the teeth, along with neighboring tabs to "bracket" the desired shade. This helps the laboratory technician determine the proper color relationship.*

tab. Photographs should be taken from various angles. This will allow the technician to better judge translucency, color, and surface texture.<sup>10</sup> The photographs should range from full smile to several teeth.

Variations can occur with cameras, monitors, and printers that may render inaccurate color. One way to correct this problem is by using color-correct software and monitor-calibration software to match the images between the dentist's and the technician's monitors. A simpler method is to photograph the desired shade tab along with two adjacent

ones to "bracket the shade."<sup>5</sup> This will enable the ceramist to adjust for these color variations because they know the color of the shade tabs represented in the photographs.<sup>11</sup>

The lighting in the laboratory should mimic the lighting in the clinical dental environment.<sup>6</sup> For example, if the dentist has a blend of natural light and color-corrected fluorescent light, then the technician should have the same. This is important as it can influence the appearance of the monitor, and of printed photographs, shade tabs, and the final restoration. The resto-

ration may look good in the laboratory, but it may look different in the dental office if the lighting is not coordinated.

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Lastly, no matter how a shade is selected, how many photographs are taken, and regardless of what type of high-tech instrumentation is used, it is still necessary to have a laboratory technician who can inter-



*Figure 4: The color of the prepared tooth is taken. This information is important for the ceramist to determine how much of the preparation needs to be blocked out to achieve the desired final appearance.*



*Figure 5: The restoration is held in line with the non-desiccated teeth to determine if the shade is approximately correct prior to try in.*

pret the data and transform it into a beautiful porcelain restoration. A dentist needs to find a talented ceramist and develop a strong working relationship with him or her. This involves setting mutual protocols and expectations.

## CLINICAL PROTOCOL

### ASSESSMENT

An adult female presented with an existing restoration on tooth #7 (Fig 1). The porcelain-fused-to-metal (PFM) crown had been placed on a discolored endodontically treated tooth 14 years earlier, and no longer matched her adjoining teeth after she whitened them (Fig 1). Although the restoration was sound and functioning, the patient wished to have it replaced for esthetic reasons. An all-ceramic crown was chosen to restore this tooth.

### PREOPERATIVE

Prior to photographs for laboratory communication, the anterior teeth were cleaned with pumice and water, with care taken not to cause any gingival bleeding. It must be emphasized that while taking pho-

tographs or during shade selection, the teeth cannot be allowed to become desiccated. The drying of the teeth will change their appearance and give an inaccurate shade and thus, inaccurate photographs to the laboratory. A simple way to prevent this is to have the chair-side assistant keep the teeth wet with moist gauze or with water from the three-way syringe, and to remind the patient to close their lips when not being photographed.

The preoperative photographs give information to the technician about both the existing restoration but, more importantly, about the adjacent teeth (Fig 1). Vita's Easyshade spectrophotometer was used on the contralateral tooth to select a shade (Fig 2). Prior to the use of the device, it was visually determined that #10 was typical of the maxillary anterior teeth and was not an aberration.

Once the shade was selected, the corresponding Vita Master 3-D shade tab was held, along with adjacent shades, in line with the incisal edges of the teeth and the tab designations visible (Fig 3). This "brack-

ets" the selected shade and the positioning gives a truer comparison to the natural teeth. Note that the selected shade is the one that corresponds most closely to the body of the tooth.

### PREPARATION

Once the existing restoration was removed and the preparation was refined, a "prep" or "stump" shade photograph was taken with a Die Material shade tab (Ivoclar Vivadent; Amherst, NY) (Fig 4). Almost any shade guide can be used to roughly determine the color of the prepared tooth. This is important, as the laboratory technician needs to know how much block-out has to be built into the restoration to achieve the desired appearance. The more translucent the proposed restoration, the more critical this step becomes. Restorations can vary from opaque (e.g., PFM) to semi-translucent (e.g., zirconia oxide and aluminous oxide) to more translucent (e.g., pressed ceramic and feldspathic porcelain).<sup>12</sup>



*Figure 6: The crown is photographed from various angles and distances during the try-in phase to ascertain if the appearance is acceptable.*



*Figure 7: Images of the restoration after it has been cemented in place. Note the color match and the similar translucency, surface texture, and characterizations to those of the adjacent teeth.*

#### RESTORATION EVALUATION

Once the restoration is received from the laboratory, it should be checked to ensure that it approximates the shade tab selected. If it is not close, the lab needs to be contacted and the restoration returned. The diagnostic information then needs to be reviewed with the technician to determine the cause of the error.

After the restoration has passed the initial evaluation, it then can be evaluated with the patient. Without desiccating the teeth, the crown is held in line with the patient's adjacent tooth to check that the shade is "in the ballpark" (Fig 3). If its appearance is approved, the temporary crown can be removed from the tooth and the ceramic crown tried in.

With the final crown un-cemented and care being taken to avoid desiccation, the tooth is checked for appearance and then it is photographed from different angles and distances (Fig 3). The digital photographs are then viewed in the office by the dentist to further evaluate the match. In addition, the patient is asked to look at the smile in a mirror.

If the patient approves the esthetics and the clinician is satisfied with the appearance, fit, and occlusion, the restoration can be seated. The patient is asked to sign a brief form stating approval of the crown's esthetics, and understanding and agreement that any changes afterward will involve a fee.

#### PLACEMENT AND TROUBLESHOOTING

Depending on the translucency of the restoration, if, at the try-in phase, the shade is "off" slightly, the appearance can be adjusted via the color of the cementing or bonding medium. This can be accomplished using try-in pastes that match the bonding material and repeating the evaluation process. If changing the cement color does not improve the esthetics or the restorative material lacks translucency (e.g., PFM) to be affected by the cement choice, then the restoration itself needs to be adjusted. In the clinical case presented here, the crown matched well without any try-in paste, so the cement color chosen for final placement was "clear" (Fig 4).

Usually in these cases, errors occur in the chroma and value. Rarely

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is it the hue, especially if an electronic shade-matching device is used. Therefore, if the chroma is too low or the value too high, the restoration can be stained chairside with tints to achieve the appropriate appearance. Then the stained restoration, along with photographs of it in the mouth, is sent back to the laboratory for the technician to revise.

If the restoration has too much chroma or is too low in value, the problem is a bit more complex. A call to the lab can determine if any surface tints or stains are present. If so, polishing of the surfaces will remove the surface coating and decrease the chroma and raise the value. If surface staining is not present, photograph the restoration with the bracketed shade tabs and return it to the laboratory. The technician will then need to re-layer the porcelain to correct the discrepancies.

## DISCUSSION

When treating a tooth in the esthetic zone, the appearance of the restoration takes on as much importance as the fit and occlusion. If the visual quality is deficient, the patient will not be satisfied. The clinical protocol described here can greatly increase the accuracy of shade matching; and decrease the time, expense, and frustration of all involved. Because no procedure is foolproof, it may be prudent for the dentist to adjust the restorative fee to compensate for the increased time needed to treat a tooth that is easily visible. Furthermore, the patient should also be informed of the potential for multiple visits to achieve a satisfactory result. With a definitive step-by-step methodology in place, matching a shade is less stressful and more precise.

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